Central Valley Salinity Project

Final Draft Report

Initial Draft

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SUMMARY

1 INTRODUCTION

http://www.waterboards.ca.gov/centralvalley/cv-salts/index.html

Overview

Elevated salinity in surface water and groundwater in California's Central Valley is an increasing problem affecting much of California, other western states, and arid regions throughout the world. As surface and groundwater supplies become scarcer, and as wastewater streams become more concentrated, salinity impairments are occurring with greater frequency and magnitude. The Central Valley Water Board and State Water Board have initiated a comprehensive effort to address salinity problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is the resulting joint effort to develop and implement a comprehensive salinity management program. The goal of CV-SALTS is to maintain a healthy environment and a good quality of life for all Californians by protecting our water.

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1.1 Statement By Dr. Karl Longley Regarding Salinity Policy Development

NEWS RELEASE

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FOR IMMEDIATE RELEASE
16 March 2006

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STATEMENT BY DR. KARL LONGLEY REGARDING SALINITY POLICY DEVELOPMENT

This Regional Board, with the cooperation of the State Board, is beginning the process of developing a new policy for regulation of salinity in the Central Valley. The purpose of a new policy for regulation of salinity in the Central Valley is to assure a sustainable surface and ground water supply for all users of Central Valley water, both within the Region and throughout much of the State. The successful development of this policy more than likely will require the extensive revision of the two Central Valley basin plans and the Bay-Delta plan. An expected, important outcome of this effort would be the development and implementation of a salt management plan.

This effort will not be easy. The necessary updating of the basin plans to address salinity issues will be an expensive and lengthy process with the source of funding for this effort being unknown at this time. Design, construction and operation of infrastructure necessary to control salinity also will be expensive. This effort will require the work of many agencies and interests, and that work will take a very long time, conceivably many decades for full implementation. Failure to control salinity, however, will result in continued decline of Central Valley water quality at an enormous cost to all water users, eventually creating even greater hardship for the environment, agriculture, industry, municipal utilities, and the entire economy of the Valley and the State. A very conceivable result if we are not successful in this effort is the stagnation and/or decline of the Valley economy with loss of jobs and opportunity for many, many Valley residents.

Recognizing that the outcome of a final policy may result in changes to the current regulatory approach, many parties affected by the Board's current approach to control salinity have already requested Board staff to delay any action until the "new" policy is developed and, as a Board member, this is a concern to me and should be to this Board. We are at the infancy stages of policy development and while we all recognize the importance of this policy, we are still too early in the process to be certain it will proceed forward. Therefore, we need to continue to exercise our authority to regulate discharges of salt to minimize salinity increases within the Central Valley. We cannot solve the salinity problem just by controlling discharges, and we must be reasonable in prescribing salinity standards and compliance schedules. However, if we do not continue to control saline discharges, water quality will continue to rapidly degrade and the magnitude of the problem to be mitigated will be much greater. The process of developing new salinity control policies does not, therefore, mean that we should stop regulating salt discharges until a salinity Policy is developed. In the meantime, the Board should consider all possible interim approaches to continue controlling and regulating salts in a reasonable manner, and encourage all stakeholder groups that may be affected by the Regional Board's policy to actively participate in policy development.

I believe this undertaking to be a very arduous but necessary undertaking by this Board if we are to ensure that the Central Valley in the future enjoys the quality of its waters necessary to ensure a healthy environment and a good quality of life for its residents.

[Delivered at the regular public meeting of the Central Valley Regional Water Quality Control Board]

California Environmental Protection Agency

1.2 Scope of Work

This study assesses the economic and social impacts of increasing salinity in the Central Valley if a comprehensive salinity management program is not implemented. Economic and social impacts will occur in the Central Valley as salinity levels increase, creating changes in water quality, water supply, the production of goods and services, income and employment.

The Central Valley is defined in the Water Quality Control Plans for the Sacramento and San Joaquin River Basins (5A/5B) and the Water Quality Control Plan for the Tulare Lake Basin (5C). Although the Sacramento-San Joaquin Delta is included in the Sacramento and San Joaquin Basin Plans, for the purposes of this study, it will be delineated as a separate region due to it's importance in determining water supply and quality for the San Joaquin Valley, and the Tulare Basin.

For this study, the status quo, or project without, is defined as not implementing a comprehensive salinity management program. Economic and social outcomes of the status quo will include changes in the production of goods and services (gross regional product), income and employment due to increases in salinity levels under existing policies and regulations.

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Economic impacts of not implementing a salinity management program will be empirically estimated by comparing two sets of economic projections. Neither of these projections specifically involves the comprehensive salinity management program since it has not been defined or specified. The first set of projections assumes the status quo and no changes in water or land quality. Therefore a proxy for the salinity policy must be formulated. Standard projections of economic activity usually do not consider resource limitations such as land, water or the effects of pollution on economic activity. This condition is the outcome of a comprehensive salinity policy. The second set of projections includes the effects of increased salinity levels on land and water use. The difference between the two sets of projections is the economic impact of increased salinity or of not implementing a comprehensive salinity management program.

The most important part of this analysis is to project future economic activity under a set of realistic assumptions and conditions relevant to the 2030 time horizon. These assumptions and conditions fall into two types. The first set of assumptions and conditions involve institutional, economic and physical changes that will directly affect water supply, land use and economic activity during the period of analysis. The Central Valley's water supply is significantly affected by changes in water rights, the Sacramento-San Joaquin Delta, out-of region water demands and climatic conditions. Land use is largely affected by population and land use planning determined at the urban and county level. Because agriculture is a significant industry in the Central Valley, changes in land productivity will also affect land use. The demand for goods and services is mostly the result of domestic market conditions, international trade agreements and government commodity programs.

The second set of assumptions relates to the effectiveness of existing water quality policies and regulations primarily administered by the state and regional Waterboards. This will involve a review of the Basin Plans and associated water quality regulations. The Basin Plans specify existing uses of water and water quality requirements to facilitate those uses. Basin Plans are updated as regulations are developed and adopted by the respective Regional Water Quality Control Board. Every two years, water quality impaired water bodies are specified as a 303(d) listed water body. The a Total Maximum Daily Load (TMDL) program is developed and implemented to reduce discharges for the 303(d) listed water body. The adopted TMDL will then become part of the Basin Plan. Other water quality programs that will be evaluated are regulations on discharges to land (Waste Discharge Requirements), regulations of discharges to water (National Pollution Disposal Elimination System). Probably the most important program in determining future salinity conditions in the Central Valley will be how the Waivers for Discharges from Irrigated Agriculture evolves as a monitoring and regulatory device. This review will serve as a basis to make assumptions regarding the effectiveness of future water quality policies and regulations. This information will also be used to specify changes in the cost of complying with those programs and regulations.

The next step is to project dischargers' reactions to the implementation of future water quality regulations. The ability of dischargers to adjust production and practices as regulations are implemented can be substantial. Regulations will be imposed over a relatively long period of time and some dischargers may have technological options to meet the more restrictive discharge limits and/or to be able to pass costs on to consumers or the next level of production. In other cases, the full cost of complying with the regulations will have to be met by dischargers located in the region. All dischargers subject to water quality regulations will be assessed as to their capabilities to meet existing water quality regulations. Economic sectors most likely to be affected by future water quality regulations are, but not limited to, municipal water and wastewater treatment plants, water purveyors, irrigated agriculture, confined animal operations, agri-business, food processing, and petroleum production.

Projecting economic activity and social conditions to 2030 is accomplished by the use of the REMI model (http://remi.com/). This is an accounting tool that will sum economic impacts across regions and over time. REMI projections of gross regional product, income and employment will be made for the state. The model will projects valley economic activity to 2030. These results are then compared to projections of economic activity when salinity effects are accounted for. The difference in economic activity can then be attributed to increases in salinity levels.
So far, only market values have been discussed. Just as important are the non-market values. These can be estimated by eliciting perceived personal opinions regarding water quality and land conditions using standard survey procedures. This procedure yields values of benefits that can be realized through the implementation of a comprehensive salinity program. Non-market values are also not usually included in

standard economic analyses. By including them in this salinity study, the total impacts to society are identified.

1.3 Objectives

The purpose of the study is to project economic impacts to 2030 if salinity controls and reduction are limited to existing regulations and programs. Among the major issues is to determine the direct and indirect effect of increasing salinity on water demand and usage in various sectors—urban, environmental and agricultural. In particular:

1. Estimate the economic impacts to 2030 of not implementing a comprehensive salinity management program by projecting gross domestic product, income and employment with and without the effects of increased salinity levels of land and water resources.

2. Determine future water supplies and quality, land use availability and capabilities and markets for goods and services produced in the Central Valley.

3. Assess the capabilities of existing water quality policies and regulations to improve salinity conditions in the Central Valley.

4. Project the capabilities of firms and consumers to cope with increased salinity levels and existing water quality regulations.

5. Estimate the non-market value of implementing a comprehensive salinity policy using established standard survey and estimation techniques.

6. Assist in developing a long-term salinity management plan for the Central Valley.

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2 BASELINE ASSUMPTIONS ON FUTURE WATER QUALITY POLICIES AND REGULATIONS

2.1 Population Projections and Economic Development

This section provides a description of baseline population growth projections from 2005 to 2030 for the Sacramento, San Joaquin, and Tulare basins. These projections are based on the REMI model. REMI uses the cohort-survival method, which models population as the natural change in population caused by births and deaths plus the net migration change for the study region. Migration is assumed to have two components where one is due to economic conditions and the other is not. When a region experiences an increase in wages, employment opportunities, and the consumer amenities that come with economic growth, people are attracted to that region and migration increases. Migration can occur for non-economic reasons too. For example, retirement, international, and returning military related migration is assumed to occur for reasons that are not directly related to the economic conditions of a specific region. Data for REMI's population projections come from the most recent US Census data and U.S. Bureau of Economic Analysis data.

Economic Development will be discussed in terms of Total Employment, Real Disposable Personal Income, and Output as estimated by REMI. Total Employment is the total number of jobs comprised of farm, government, and private non-farm employment. Real Disposable Personal Income in a region is personal income adjusted for taxes and the cost of living specific to the region. Personal income is primarily compensation plus proprietors' income, property income, and transfer payments (government payments such as social security, welfare, or education grants). In this study, real disposable income is measured in (standardized to) 2000 dollars (2000$). Output is comprised of the goods and services produced in a given region that is sold to consumers, other firms, investors, and governments outside the region. This includes international export. Output requires inputs that include labor, capital, fuel, and intermediate goods. Like real disposable income, output is measured in 2000 dollars.

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The industries that will be included in this study are Forestry, Agriculture, Mining, Utilities, Construction, and Manufacturing. Manufacturing will be further divided into Food Processing; Beverage and Tobacco Products manufacturing; and Other. The Food Processing and Beverage and Tobacco products categories are intended to capture the output of the food processing and wine making industries. Other is likely to dominate because it includes many sub-industries and some very high valued output such as computers, electronics, petroleum, and pharmaceuticals. With the exception of Manufacturing, the study uses the highest level of industry aggregation available in REMI. The aggregation scheme used by REMI is the North American Industry Classification System (NAICS). For details of what more specific sub-industries are include in each category, please refer to the REMI Policy Insight User Guide Version 9.0 or to

For a more detailed discussion of population and economic development variables, their calculations and adjustments, see the REMI Policy Insight Model Documentation Version 9.0.

2.1.1 Sacramento Basin Projections

The population in the Sacramento Basin in 2005 was approximately 3,412,000 people and the estimated population in 2030 is 4,795,000 people. This change represents an increase of 1.4 million people or a 40.6% increase in population over the study period.

Among the three study regions, the Sacramento Basin has the highest total employment at approximately1,810,000 jobs in 2005. This level is expected to grow to 2,393,000 jobs by 2030, which is an increase of 32.2% or just over 583,000 jobs. Real disposable income was approximately $82,215,000,000 in 2005 and is projected to grow to $144,519,000,000 by 2030. This represents a growth of $62.3 billion or 75.8%. Output was estimated at $139,659,000,000 in 2005 and is projected to grow to $286,909,000,000 by 2030. This represents a growth of nearly 140.0% or just over $204 billion.

Figure 2.1.1graphically shows the growth in population, employment, real disposable income, and output for the Sacramento Basin over the study period. The trend for each metric steadily increases over time with no apparent sudden dips or spikes.

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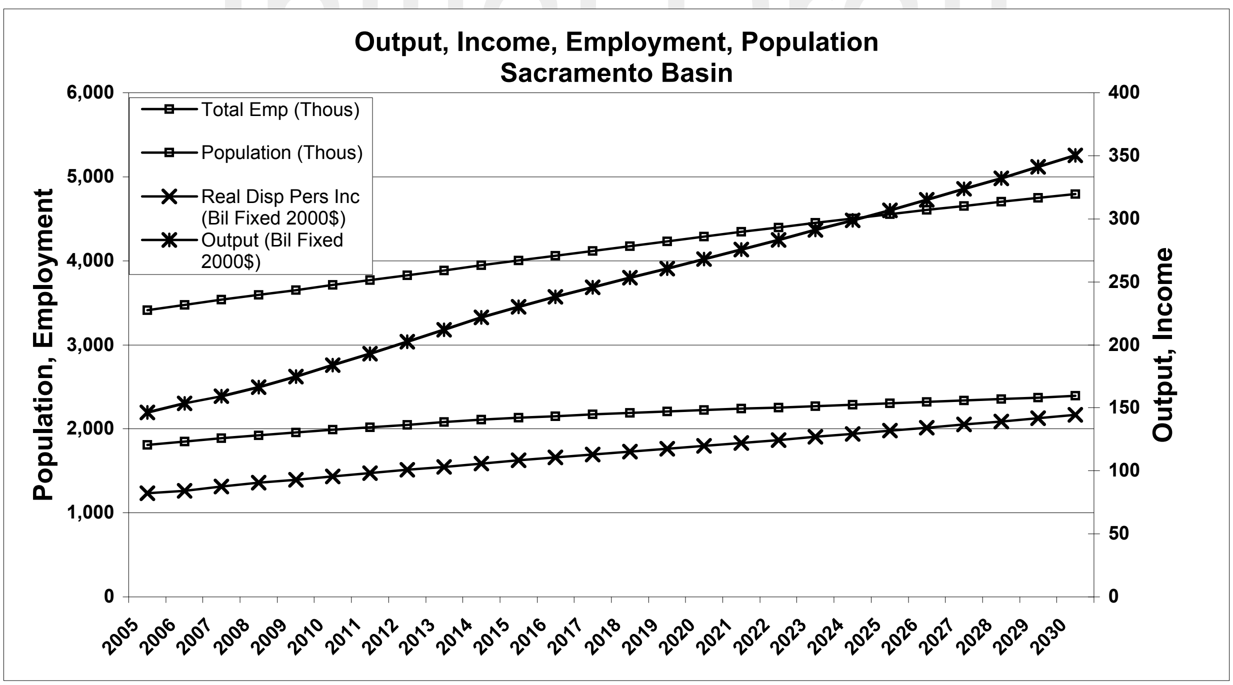

Figure 2.1.1 Output, Income, Employment, Population, Sacramento Basin

The largest industry in the Sacramento Basin is manufacturing with output of just over $25 billion dollars in 2005. Food processing represents 13% of Manufacturing while

Beverage and Tobacco Products (BTP) manufacturing represents about 8%. The remaining manufacturing sub-industries, grouped as “Other”, make the up the bulk of the output at 79%. Overall, Manufacturing is expected to grow to $78 billion by 2030 for a 212% expansion. The second largest industry in the Sacramento Basin is Construction with output valued at $12.5 billion in 2005 and expected to grow to $21 billion, or 67%, by 2030. Utilities is a distant third largest industry at $2.73 billion in 2005 and expected to expand by 64% by 2030. Forestry, Agriculture, and Mining together comprise $1.2 billion of output in 2005. Forestry output is expected to increase 47%, Agriculture 51%, and Mining 62% by 2030. Table 2.1.1 summarizes the output and changes in output for the Sacramento Basin.

Table 2.1.1. Sacramento Basin Output (Billions Fixed 2000$)

Industry	Year		Difference 2005 to 2030	% Change
	2005	2030		
Forestry	0.581	0.854	0.273	47.0%
Agriculture	0.222	0.336	0.114	51.4%
Mining	0.418	0.677	0.259	62.0%
Utilities	2.73	4.48	1.75	64.3%
Construction	12.53	21.11	8.58	68.5%
Manufacturing	25.08	78.36	53.29	212.5%
Food	3.29	5.30	2.02	61.4%
BTP	1.98	2.59	0.61	30.8%
Other	19.81	70.47	50.658	255.7%

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2.1.2 San Joaquin Basin Projections

Population in the San Joaquin Basin is expected to grow by 38.5%, which represents just over 1 million people between 2005 and 2030. The population in the San Joaquin Basin in 2005 was 2,704,000 people and is projected to be 3,744,000 by 2030.

Estimated total employment in the San Joaquin Basin in 2005 was 1,233,000 jobs, which is projected to be 1,584,000 in 2030. This represents a growth of 28.8% or about 351,000 jobs. The real disposable income in 2005 was approximately $69,076,000,000 and expected to grow 73.3% to $119,716,000,000 by 2030 for a difference of $50.6 billion. With respect to output, it was approximately $139,659,000,000 in 2005 and expected to be $286,909,000,000 by 2030. This is an increase of $147.3 billion or growth of 105.4%.

Figure 2.1.2 illustrates the levels of the growth in population, employment, real disposable income, and output for the San Joaquin Basin over the study period. The trend for each metric steadily increases over time with no apparent sudden dips or spikes.

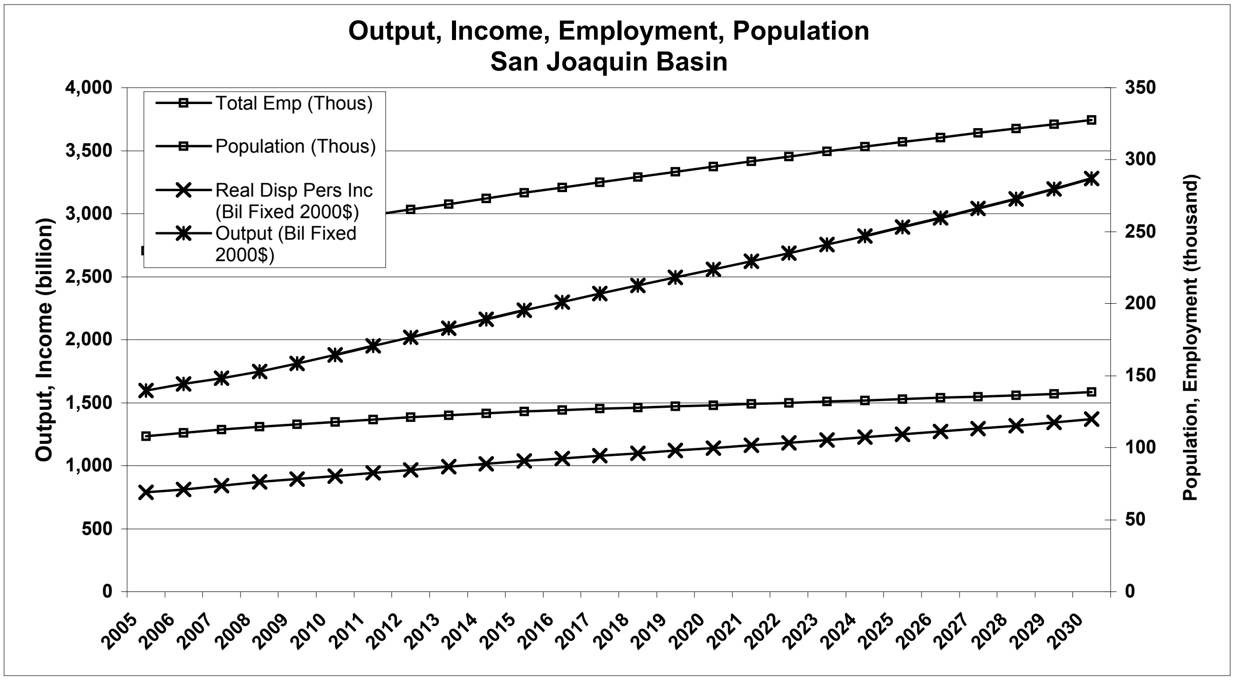

Figure 2.1.2. Output , Income, Employment, Population, San Joaquin Basin.

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Table 2.1.2 summarizes output by industry in the San Joaquin Basin. Manufacturing is the largest sector with $44.6 billion of output in 2005, which is estimated to grow to $79 billion by 2030. Food processing is nearly 18% and Beverage Processing and Tobacco Products (BTP) manufacturing is nearly 5%. The balance of manufacturing is the bulk of the output at approximately 78%. Like the Sacramento Basin, Construction was second in output at $9.4 billion in 2005 and Utilities was a distant third at $2.3 billion; and expected to grow 63% and 58% respectively by 2030. Mining, Agriculture, and Forestry are lowest in output with $1.7 billion, $406 million, and $208 million respectively in 2005. By 2030, Mining is projected to grow 33%, Agriculture by 53%, and Forestry by 55%. Mining in the San Joaquin basin is primarily oil and gas exploration.

Table 2.1.2. San Joaquin Basin Output (Billions Fixed 2000$)

Industry	Year		Difference 2005 to 2030	% Change
	2005	2030		
Forestry	0.208	0.323	0.115	55.3%
Agriculture	0.406	0.619	0.213	52.5%
Mining	1.56	2.07	0.518	33.3%
Utilities	2.25	3.54	1.29	57.5%
Construction	9.40	15.27	5.87	62.5%
Manufacturing	44.63	79.08	34.45	77.2%
Food	7.88	12.76	4.88	61.9%
BTP	2.09	2.80	0.71	33.8%
Other	34.66	63.53	28.87	83.3%

2.1.3 Tulare Basin Projections

The Tulare Basin is the least populated among the three basins in the study area. In 2005, the population was estimated at 2,189,000 people and is expected to grow to 2,844,000 people by 2030. This represents a 29.9% growth or just over 655,000 people.

The Tulare Basin had a total employment level of 1,030,000 in 2005. This level is projected to increase to 1,220,000 by 2030. This represents approximately 190,000 new jobs or a 18.5% growth. Real disposable income in 2005 was estimated at $42,162,000,000 and projected to be at $67,399,000,000 by 2030. This is a growth of 59.9% or $25.2 billion. Regarding output, it was estimated at $71,074,000,000 in 2005 and expected to be $137.629,000,000 in 2030. Output will have grown by about $66.6 billion or by 93.6%.

Figure 2.1.3 summarizes the levels of the growth in population, employment, real disposable income, and output for the San Joaquin Basin over the study period. The trend for each metric steadily increases over time with no apparent sudden dips or spikes.

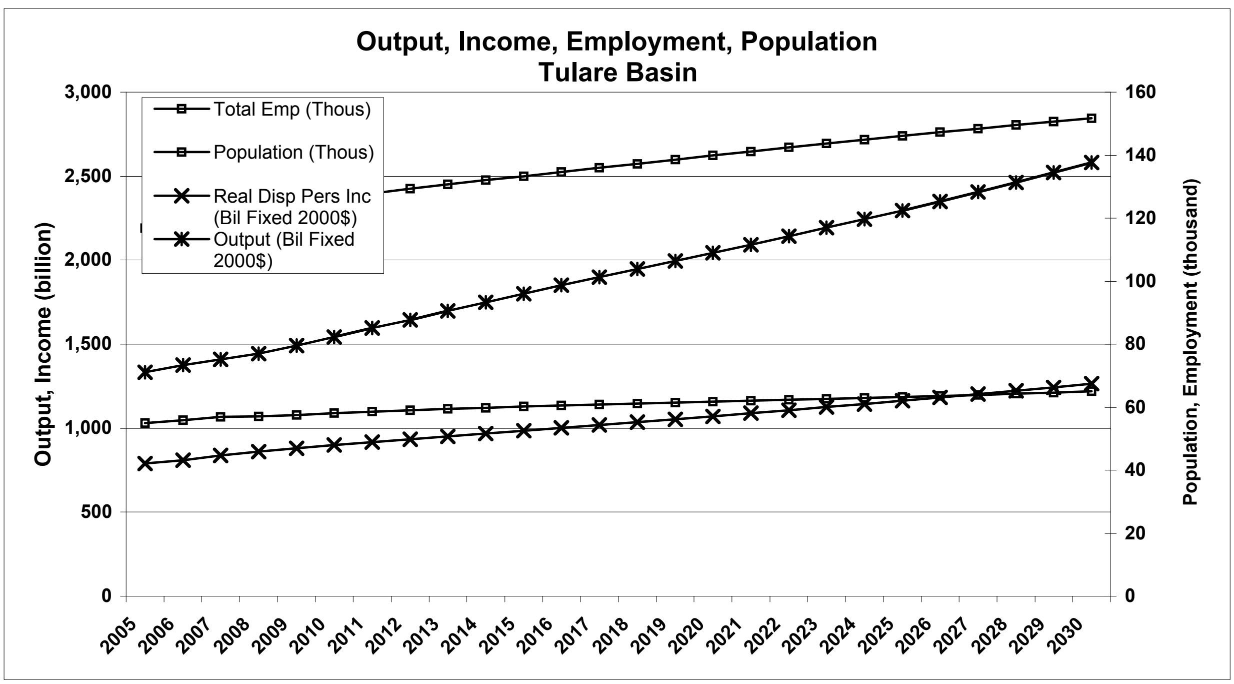

Figure 2.1.3. Output, Income, Employment, Popultaion, Tulare Basin

The manufacturing output in the Tulare Basin in 2005 was estimated at $16.8 billion with food processing representing 44% of the output, Other representing 52%, and Beverages and Tobacco Products representing about 4%. By 2030 Manufacturing output will increase by approximately 83% with Food Processing increasing by 59%, BTP by 37%, and Other by 106%. Construction output in 2005 was $5.2 billion and expected to increase to $7.8 billion by 2030. Unlike the Sacramento and San Joaquin basins, Mining is a larger component of Tulare Basin's output. Mining output was valued at $4.6 billion in 2005 and is estimated to grow by 33% to $6.1 billion by 2030. Mining is predominantly Oil and gas exploration. Utilities ranks fourth in output and Forestry ranks sixth. Agriculture ranks fifth and was valued at $1.3 billion in 2005 and is expected to grow by 44% to $1.8 billion in 2030. As compared to the Sacramento and San Joaquin basins, the Tulare Basin supports higher valued agricultural production such as animal production and the services needed to support confined animal operations.

Table 2.1.3 Tulare Basin Output (Billions Fixed 2000$)

Industry	Year		Difference	% Change
	2005	2030	2005 to 2030	
Forestry	0.045	0.071	0.026	57.8%
Agriculture	1.25	1.80	0.553	44.4%
Mining	4.61	6.12	1.51	32.9%
Utilities	2.06	3.09	1.03	49.8%
Construction	5.15	7.78	2.64	51.2%
Manufacturing	16.80	30.66	13.86	82.5%
Food	7.39	11.71	4.32	58.5%
BTP	0.63	0.86	0.23	37.2%
Other	8.78	18.08	9.30	105.9%

2.2 Waste Discharge Requirements for Irrigated Agriculture Waiver Program

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The California Water Code gives authority to the State and Regional Water Boards to conditionally waive waste discharge requirements (WDRs) when it is in the public interest to do so. Agriculture is a vital industry to California and to the nation in terms of its prolific ability to produce food, feed, and fiber domestically and internationally. Regional Water Boards, issue waivers for over 40 types of discharges. Those from agricultural lands include irrigation return flows, flows from tile drains, and storm water runoff because they can carry constituents such as salinity, nutrients, pesticides, sediment, pathogens, and heavy metals to surface water bodies. These constituents can travel further along the water cycle into lakes, reservoirs, rivers, estuaries, and eventually groundwater and the ocean. Statewide, approximately 9,500 miles of stream and rivers and approximately 513,000 acres of lakes and reservoirs are listed on the 303(d) list as being impaired by irrigated agriculture. (SWRCB(b), 2006)

WDR waivers have historically been conditional and required that discharges do not violate water quality objectives. However, the waivers did not require any water quality monitoring and management plans. Senate Bill 390 was signed into law in 1999 and amended California Water Code section 13269. The amendment required the Regional Water Boards to review existing waivers, renew them or replace them with WDRs, enforced the conditions of the waivers, and to reconsider the renewal of waivers every 5 years. In 2003, section 13269 was amended again to authorize the State Water Board to establish and collect fees for waivers. To comply with these changes, the Regional Water Boards adopted waivers to regulate most of the categorical discharges, such as agricultural waivers. The Central Valley Water Board, along with the Central Coast and

Los Angeles Water boards, modeled agricultural waivers using regulatory models specific to agriculture and implementing extensive enrollment, education, and public outreach programs in their regions. Please see the "Fact Sheet Fee Proposal for Agricultural Waivers" and "About Agricultural Waivers" at http://www.waterboards.ca.gov/agwaivers/ for additional details on waivers, fee schedules, and program information.

The Central Valley regional conditional agricultural waivers (R5-2006-0053 and R5-2006-0054, adopted June 22, 2006) cover discharges of waste from irrigated pasture, field and row croplands, rice fields, orchards, vineyards, commercial nurseries, nursery stock producers, greenhouses with permeable floors (not regulated under other permits), and managed wetlands such as wildlife refuges and duck clubs. These waivers relinquish requirements to obtain WDRs, submit waste discharge reports, and payment of filing fees. However, the waivers have implemented a monitoring and reporting program to measure compliance of the terms and conditions of the waiver, as required by the Water Code. The program is known as the Irrigated Lands Conditional Waiver Program and is an interim program.

Since implementation of the Irrigated Lands Conditional Waiver Program, the Central Valley Water Board has held many workshops and meetings with stakeholders, such as coalition groups, the Farm Bureau, agricultural commissioners, resource conservation districts, water districts, environmental interests such as Delta Keeper, and other interested stakeholders affected by the agricultural community. To maintain the continued identification of program needs, the Regional Water Board is working with the coalition groups, individual dischargers, water districts, UC Davis Cooperative Extension, State Board programs, and Regional Board programs. An objective of the Irrigated Lands Conditional Waiver Program is collect sufficient data and information to develop and support a long-term regulatory program. An Environmental Impact Report is being prepared to further the development of a long-term regulatory program. (SWRCB(c), 2006).

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2.3 Clean Water Act Section 303(d) List of Impaired Water Bodies and TMDL Projects

Section 303(d) of the Federal Clean Water Act (CWA), enacted in 1972, requires states to compile a list of surface water bodies that are not attaining water quality standards after best available technology has been utilized to maintain a target minimum level of polluting constituents. This list is commonly known as the 303(d) list. For listed water bodies, states are required to develop total maximum daily loads (TMDL), accounting for all sources of the pollutants that caused the water to be listed. Federal regulations require that TMDLs account for pollutants from point sources and contributions from non-point sources, which are significantly more difficult to identify, quantify, and control. US EPA is required to review and approve the list of impaired water bodies and each TMDL. If US EPA cannot do so, then US EPA must establish the 303(d) and/or the TMDLs for the state.

The US EPA requires that implementation plans be developed as part of TMDLs and that the permits for point source discharges under the National Pollutant Discharge Elimination System (NPDES) be consistent with any approved TMDL implementation plans. California's Porter-Cologne Water Quality Control Act requires that TMDL implementation be addressed by incorporation into Basin Plans, known as Basin Plan amendments.

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The Central Valley region has Basin Plans for the Tulare Lake Basin and one for the combined Sacramento and San Joaquin river basin. These plans were initially adopted in 1975 with major revisions 1984, 1989, 1994 and 1998. As an integral part of the basin planning process, every three years the Region reviews the existing plans for need to modify existing standards and to redefine basin planning priorities if necessary. Water quality standards in California are defined by two pieces of legislation. Title 40, Code of Federal Regulations, Part 131 requires each state to designate beneficial uses of water that need to be protected. The Porter-Cologne Act also requires Regional Board to establish water quality objectives to ensure the reasonable protection of beneficial uses.

For detailed discussion of listing, delisting, and area changes for the Central Valley water bodies on the 303(d) list see the documents at http://www.waterboards.ca.gov/tmdl/303d_update.html. For details and documents related to the Central Valley Region's Basin Planning Program and TMDL based amendments see http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/index.html. For a discussion of the TMDL process and a copy of the 303(d) list, see http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/index.htm.

2.4 Concentrated Animal Feeding Operations

The primary federal environmental legislation affecting animal production is the Clean Water Act (CWA). The largest of the animal feeding operations (AFOs[1]), defined as concentrated animal feeding operations (CAFOs)[2], are required under the CWA to obtain a National Pollution Discharge Elimination System (NPDES) permit, which specifies how manure disposal is managed by each CAFO. In general, NPDES permits are required by point sources (facilities that discharge directly to water resources through a discrete ditch or pipe) before they can discharge into navigable waters. The permits specify a level of treatment for each effluent source. Agriculture is typically exempted from NPDES requirements. However, under regulations developed by EPA in 1974, certain AFOs can be designated as CAFOs and be considered a point source under the NPDES program (Ribaudo, et al., 2003).

Effluent Limit Guideline, which establishes the discharge goal for facilities requiring a NPDES permit, found in the original CAFO regulations allow no discharge of pollutants to waters except in the event of a 25-year, 24-hour storm (40 C.F.R. § 412). The original CAFO regulation also provided an exemption for poultry operations that used dry manure handling systems. These provisions, notably, were applied only to the animal production facility. The original CAFO regulation presumed that manure removed from the production area was handled appropriately through land application. Land application of nutrients was traditionally treated as a nonpoint-source pollution issue, and as such, not regulated under the Clean Water Act(Ribaudo, et al., 2003). For its part, California has also implemented regulations for controlling the environmental impacts of AFOs that are meant to address the problems associated with agricultural production methods including pollution discharge permitting, effluent limits, and land application plans (USEPA 2002).

The federal regulatory landscape changed for all AFOs in 1999 when the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA) announced their Unified National Strategy for AFOs (USDA-EPA 1999) in response to the increased concentration of animal production throughout the United States. The

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[1] EPA regulations (contained in 40 C.F.R. §122.23 and Part 122, Appendix B) define an AFO as a facility where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and crops, vegetation, forage growth, or postharvest residues are not sustained in the normal growing season over any portion of the lot or facility where the animals are housed. This does not include fields where manure might be spread.

[2] A CAFO is defined as an AFO that confines more than 1,000 animal units (AUs), or between 301 and 1,000 AUs and discharges pollutants into waters through a manmade ditch, flushing system, or similar manmade device, or directly into waters that pass through the facility, or is determined to be a significant contributor of pollutants to U.S. waters. An animal unit is equivalent to 0.7 dairy cows, 1 slaughter and feeder cattle, 2.5 swine weighing more than 25 kg, 30 laying hens or broilers if a facility uses a liquid manure system, and 100 laying hens if a facility uses continuous overflow watering Gollehon, N., et al. (2001) "Confined Animal Production and Manure Nutrients." Economic Research Service, USDA, Bulletin No. 771,Washington, D.C.

Strategy established a framework of actions that USDA and EPA would take, under existing legal and regulatory authority, to minimize water quality and public health impacts from improperly managed animal manure. The Unified Strategy, when fully implemented, would set minimum standards for all State water quality protection programs. The Unified Strategy established the goal that all AFO owners and operators develop and implement technically sound, economically feasible, and site specific comprehensive nutrient management plans for properly managing the animal manures produced at their facilities, including onfarm application and off-farm disposal, if any (Ribaudo, et al., 2003). The Strategy cites land application as the most desirable method of using manure because of the value of its nutrients and organic matter (USDA-EPA 1999).

To satisfy the goals of the Unified Strategy and to mitigate actual and potential water quality impacts from CAFOs, EPA revised the regulations for CAFOs at the end of 2002 (USDA-ERS 2003) These revisions changed the requirements for a NPDES permit and their associated Effluent Limit Guidelines for CAFOs by requiring permit holders to develop and implement nutrient management plans for manure nutrients. These nutrient management plans limit the land application of manure. The limits are generally agreed to be the agronomic nutrient demand on cropland—i.e., manure generated at CAFOs is applied to cropland and pastureland at a rate no greater than the rate at which the crops can assimilate the applied nutrients, thereby minimizing nutrient runoff from the fields (USDA-EPA 1999). Other major changes for CAFO NPDES permit and Effluent Limit Guidelines include:

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•Eliminating the 25-year/24-hour storm exemption.
•Eliminating the exemption for poultry operations with dry manure handling systems.
•Making a nutrient management plan part of the NPDES permit, including land application of animal manure.
•Adopting a zero-discharge requirement with no overflow allowance for new swine, veal, and poultry CAFOs.

These new CAFO rules did not go unchallenged. In February of 2005, the U.S. Court of Appeals for the Second Circuit issued a decision on Waterkeeper Alliance et al. v. EPA. Most noteworthy from this decision was the Court's determination that EPA has the authority to regulate the runoff containing manure that CAFOs have applied to cropland. The Court also vacated the CAFO rules duty to apply provision. In the new CAFO rules, all CAFOs were required to apply for a NPDES permit unless they could demonstrate no potential discharge. The court found the argument supporting this provision to be invalid, given the CWA only applies to actual discharges rather than potential discharges.

The analysis presented in this report does not evaluate the case where manure from all AFOs is land applied at agronomic rates even thought USDA policy encourages all animal feeding operations (AFOs) to adopt nutrient standards voluntarily, and provides financial assistance for doing so. If all AFOs try to meet nutrient standards the amount of manure needing transportation within a region will increase, as well as an increase in the demand for cropland to for applying the manure at agronomic rates. Ribaudo et al.

(2003) note competition for land for spreading manure could be severe in regions with high concentrations of animals such as is in California. A glance at Figures 1 through 4 shows how stiff competition will be for land to spread manure. Figures 1 through 4 illustrate the annual excess nitrogen and phosphorus throughout the Central Valley for all AFOs and for CAFOs under the three different farmer willingness to accept manure (WTAM) scenarios.[3]

In many of the Central Valley Production (CVPM) Regions[4] excess nitrogen and phosphorus are present because these regions have insufficient cropland to assimilate the manure nutrients generated by all animal feeding operations (AFOs) or by CAFOs. Many regions throughout the Central Valley produce more manure nitrogen than can be assimilated by crops grown on surrounding acreage. Regions 1 through 7, which correspond to the Sacramento River Basin, seem best suited to handled the nitrogen and phosphorus contained in animal manure. Unfortunately, little of the manure generated throughout the valley is found in this basin. Most of the animal production and manure generation occurs south of the Delta. San Joaquin River Basin corresponding to Regions 8 through 13, and Tulare Basin to Regions 14 through 21, appear to have many regions unable to handle manure nitrogen, while all regions in these basins, except Region 9 cannot manage the manure phosphorus generated there. Consequently, operations in these regions will have to compete for available land if all manure or only manure from CAFOs were to be spread at agronomic rates. The intense competition for land for spreading manure in California will likely crowd out voluntary compliance with nutrient standards by those AFOs not defines as CAFOs.

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The analysis to follow also does not consider the financial assistance to help all AFOs adopt nutrient management plans comes from the Environmental Quality Incentive Program (EQIP) first initiated in the 1996 Federal Agriculture Improvement and Reform Act (1996 Farm Act) and amended by the 2002 Farm Security and Rural Investment Act (2002 Farm Act). EQIP provides technical assistance, cost-share payments, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm. Animal feeding operations can receive financial assistance for waste management structures and for nutrient management. By statute, 60 percent of the available funding for the program is earmarked for practices related to livestock production. EQIP was funded at about $200 million per year from 1996 through 2000 and then increased incrementally from $400 million in 2002 to $1.3 billion in 2007. Negotiations for the latest Farm Bill are underway. Among the topics being discussed is how EQIP resources will be allocated in the future. In any event, the analysis contained in this report does not consider the implications of EQIP payments in mitigating manure management concerns given the uncertainty of future payments and the perceived inability of future payments to resolve the excessive disparity between limited available cropland for spreading manure and the abundance of manure requiring land application at agronomic rates as seen in annual excess nutrients found throughout the San Joaquin River Basin and Tulare Basins.

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[3] More details on WTAM are provided below.

[4] The regional model used to analyze CAFOs is delineated along CVPM regions as is the irrigated agriculture model

In the analysis to follow we only consider manure from CAFO operations. Two CAFO scenarios are constructed to account for all CAFO manure and manure from only CAFOs with actual discharges to water in accordance with the Court's decision where only those CAFOs with actually discharges to water are required to apply for a permit. The regional approach taken in the analysis does not indentify manure from CAFOs and all other AFOs. To accommodate the distinction between CAFO manure and manure all other AFO manure, a percentage of the total manure, and thus manure nutrients, generated throughout the Central Valley is used as an approximation of the manure generated from CAFOs. The estimated quantity of manure production from CAFOs in based on estimates found in Ribaudo et al (2003), who show CAFOs were estimated to generate 65 percent of excess nitrogen and 68 percent of excess phosphorus throughout the United States and approximately 60 percent of the manure from the Pacific States (California, Oregon, and Washington) is produced by CAFOs. As such, 60% percent of all manure generated is delineated as CAFO manure. The second CAFO scenario delineates only 30% of the manure from all AFOs be applied according to nutrient constraints. Although there is considerable uncertainty about actual versus potential discharge, truthful reporting by CAFOs, and lax enforcement, this latter scenario is constructed for illustrative purposes only. As we will see in Section 3.5, even under this second CAFO scenario, consider change to be observed for future returns to AFOs, salt loads, and herd size.

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2.4.1 Implementation of Land Application Nutrient Constraints

The new CAFO regulations require that CAFO nutrient management plans be based on the most limiting nutrient for applying animal manure and commercial fertilizer to cropland. Plans would be nitrogen-based in areas where soil phosphorus is low and phosphorus-based where soils have high phosphorus content. This requirement essentially expanded the coverage of the Clean Water Act from the production facility to the land where manure is applied. The ability of CAFOs to comply with these nutrient requirements will depend on the assimilative capacity of the crops grown on surrounding lands and producers' willingness to accept manure.

The willingness of crop producers to accept animal manure from livestock and poultry operations will determine land supply and thus the overall ability of CAFOs to apply their manure. Crop producers' willingness to accept manure (WTAM) and its influence on producer costs is critical throughout the range of analyses. Among the major field crops grown throughout the United States, the share of acres treated with manure ranges from about 15 percent for corn and 10 percent for soybeans to less than 3 percent for wheat (USDA-ERS 2003). Most crop farms without livestock, and many farms with livestock, use commercial fertilizers because they are less bulky, easier to apply, and have a more certain nutrient content than manure (Ribaudo, et al., 2003). In addition, recent outbreaks of E Coli and Salmonella in the United States are assumed to further reduce farmers' WTAM as a substitute for commercial fertilizer, today and in the future. For many producers, the convenience of commercial fertilizer often outweighs the value of manure as both a source of nutrients and a soil amendment that improves the physical and chemical properties of cropland (Ribaudo, et al., 2003). For these reasons three different manure acceptance rates are considered (30%, 20%, and 10%). In section 3.5 we will see how these WTAM scenarios in conjunction with the CAFO definitions affect gross returns, salt loading, and herd size under the various scenarios presented above. We will also consider changes in cropping patterns associated with increasing salinity levels and its effect of irrigated agriculture.

2.5 National Pollution Disposal Elimination System (NPDES)

The National Pollutant Discharge Elimination System (NPDES) permit program regulates point sources that discharge pollutants into waters of the United States. Point sources are discrete discharges, such as pipes, a industrial plant, an agricultural operation, municipal wastewater treatment plants, or stormwater runoff from impervious surfaces such as parking lots that lead directly to a surface water body. Even though the NPDES is a federal requirement, many states are authorized by the US EPA to administer the program. This is the case for California where the regional water boards' NPDES Wastewater programs are responsible for regulating the point source discharges to the state's surface waters, coastal waters, and groundwater. The non-points are regulated by the Waste Discharge Requirements (WDR). For detailed information about the federal NPDES, such as permitting, permitting tools, statues and regulations, and strategic plans, see http://cfpub.epa.gov/npdes/home.cfm?program_id=45.

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For the regional water boards, the NPDES Wastewater Program has responsibility for regulating wastewater discharges to surface waters. Primary program responsibility includes (:

1. Issuing new and renewing NPDES permits
2. Monitoring discharger compliance with permit requirements through review of discharger self-monitoring reports and compliance inspections
3. Taking enforcement actions as appropriate, for example, Notices of Violations, Mandatory Minimum Penalties, etc.
4. Investigating spills and illegal discharges and
5. Handling petitions and litigation.

Three types of NPDES permits related to salinity are agricultural, Concentrated Animal Feeding Operations (CAFO), and combined and sanitary sewer overflows. According to the US EPA, the NPDES regulations exclude irrigated agriculture and agricultural stormwater runoff as requiring permits. Often the constituents related to irrigated agriculture cannot be identified to a source and as such is regulated under non-point source statutes. Discharges from concentrated animal feeding operations, concentrated aquatic animal production facilities, discharges to aquaculture projects, and silviculture are required to have the necessary NPDES permits.

Combined sewer systems convey rainwater runoff, domestic sewage, and industrial wastewater in the same pipe to municipal or regional wastewater sewage treatment plants. At the plant the waste water undergoes treatment rendering it safe for discharge to a water body. The capacity of the wastewater treatment plant can be exceeded during severe weather conditions such as a heavy rainstorm or sudden melting of snow over a wide area. At such times, the combined sewer systems are designed to overflow, discharging untreated wastewater that contains among other constituents, pathogens, industrial toxins, and solid matter into the receiving water body.

Combined sewer overflows (CSOs) are a serious water pollution concern for approximately 772 U. S. cities. Sanitary sewer systems are designed to collect only sewage and no stormwater, but are still susceptible to overflows (sanitary sewer overflows or SSO) due to infiltration of stormwater during severe weather events, poor maintenance of the system, improper operations of the system, or vandalism. The US EPA estimates that at least 40,000 SSOs occur each year. (US EPA, 2008). As urban develop continues to increase in California, the risk of CSOs and SSOs will rise.

2.6 Climate Change

The assumptions on the way that climate change will affect California's Central Valley are drawn from Tanaka et al (2006) in which the ability of California's water based economy to adapt to climate change is examined. Climate warming effects were represented for all major hydroelectric inputs, and optimal adaptation was assumed. Changes in population land-use and economic demands are also defined in Tanaka et al (2006). The basic assumptions on temperature and precipitation are derived from the Parallel Climate Model (PCM) global simulations, downscaled to the level of California watersheds and the Central Valley. The change in land use and effective water supplies by 2030, is pro-rated from the 2100 projections in Tanaka et al (2006). An implicit assumption in this approach to project in climate change impacts is that new crops, industries, and technologies will evolve to adapt to the increase in temperature and reduction in water supplies and climate change.

2.7 Surface and Ground Water Supplies and Allocations

The level of water infrastructure in operation in 2004 is assumed to continue at its current level until 2030. No new major facilities are assumed to be built, as at the time of writing, it is hard to predict any clear action in terms of changes in storage or conveyance. One obvious exception is the possibility of an alternative facility for conveyance around the Sacramento river delta. Such a facility is likely to have significant effects on both the quantity of water available in the Central Valley and an improvement in its quality and reduction in the salt load imported into the valley. This scenario will be addressed in the future. However, we do assume that the trend towards rational reallocation of existing water supplies to their highest and best use by voluntary markets will continue. Significant changes in the current level of groundwater pumping and use are not anticipated, despite the average level of groundwater overdraft in the Tulare basin. We do however anticipate a continual development of the capacity for conjunctive storage using groundwater aquifers.

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2.8 International Agricultural Markets

A significant proportion of the agricultural and processing output from the Central Valley is exported to international markets. Since it is very difficult to predict how the comparative advantage to California products will change over the next 25 years, the shift in the economic demand for California products is modeled by assuming that California will maintain its share of the growing domestic and international markets. Market growth is modeled, based on predictions of population growth both in California and the US, and the growth in relative income in these two markets. An income elasticity of demand is used to translate this change in income into an increased demand per capita for California products. The change in population enables a prediction of changed quantities demanded by consumers assuming no relative price change. This effect is modeled by shifting the crop specific demand function parameters so that prices are still responsive to production levels, but reflect the effects of competition and California production.

2.9 U.S Agricultural Policy

As with international markets, US farm policy is subject to political influences and international conditions. Most industries in the Central Valley are not greatly affected by US agricultural policy, with the exception of the dairy industry and the cotton industry. The effect of changes in subsidies on the cotton industry is likely to be reduced over time due to the shift towards Pima cotton that is not subsidized. While a change in dairy price supports would influence this major California industry, constraints on their ability to dispose of effluent analyzed in detail in section 3.5 are far more likely to be rate-limiting variable.

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3 PROJECTING ECONOMIC ACTIVITY TO 2030- NO POLICY CHANGES

3.1 Salinity Sources, Accumulations and Projections to 2030

3.1.1 Approach

Salinity accumulation can follow one of two approaches; one of salt mass balance and a second one of the total salinity mobilization. The mass balance approach calculates the net change in the total salt load, averaged over the valley. In contrast, the salinity mobilization approach calculates total quantity of salt that is moved by economic activity such as irrigation. The volumes of salt in this latter approach are approximately 10 times the net change in mass balance. The first approach is based on previous work from Orlob (1991), Shoups (2004), Shoups et al. (2005) in California's Central Valley. Both studies conclude that the net salt accumulation in the San Joaquin and Tulare valleys combined totals approximately half a million tons per year in the form of dissolved salts both shallow and deep groundwater. According to Schoups et al. (2005), salt imports by infiltration for the valley are governed by rainfall, surface water and groundwater pumping; whereas salt exports are drainage, bottom flux towards deep groundwater and lateral flows to the San Joaquin river. Thus, they hypothesize that there is an equilibrium in which irrigation water salt loads are offset by deep percolation and lateral flows. Under these assumptions, salt accumulation in the form of dissolved salts occurs at a rate of approximately 0.5 MTons/year.

A second approach for salt accumulation is to calculate the total average salt load in all be applied irrigation water. The salt load removed by drainage is subtracted, and the remaining salt load is assumed to accumulate in the area and strata where it is used. If the proper concentration is not applied for the drainage outflows and lateral flows, an overestimation of the accumulation of salt can occur. This study follows Orlob (1991) and Schoups (2005) approach.

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3.1.2 County and Regional Salt Sources and Aggregations.

Salt accumulations were estimated by the difference in amount of salt in the water supply of a water user and the amount of salt in the waste water discharged. The net difference can be attributed to the activities of the water user. Sector water use was estimated by the California Department of Water Resources in 2005.

Table 3.1.1. Central Valley Use by Basin, 2005 (1,000 AF/year)

Sector	Sacramento Basin	San Joaquin Basin	Tulare Basin	Central Valley
Agricultural	7,782	6,794	9,976	24,552
Municipal & Commercial				
Single Family Interior	140	106	126	372
Single Family Exterier	273	197	193	663
Multi-Family Interior	89	94	133	316
Multi-Family Exterier	24	47	80	151
Commercial	138	40	46	224
Urban Landscape	120	36	20	175
Total Municipal & Commercial:	784	519	598	1,900
Industrial				
Industrial	85	90	66	241
Energy	0.10	0.00	0.00	0.10
Total Industrial:	85	90	66	241
Basin and Central Valley Water Use	8,650	7,403	10,640	26,693

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3.1.3 Domestic and Commercial Salt Accumulations

Domestic salt load was estimated by the per capita water use and the difference between the salt concentration of the water supply and the waste water (Table 3.1.2). 2007 county population was estimated using REMI projections. Water use for Central Valley was estimated to be 204 gallon per day which is similar to the Sacramento Basin. Water use for the Tulare Basin was estimated at 240 gallons per day and 240 gallons per day for the San Joaquin Basin. Estimating the incremental salt concentrations for domestic water use was beyond the scope of this project so the standard placed on waste water disposal (350 ppm) was used to determine a “ball park” estimate of salt accumulations.

Total domestic salt load for the Central Valley was estimated at approximately 1.5 million ton per year. About 41 percent (600 thousand) of the total domestic salt load originates in the Sacramento Basin.

Table 3.1.2. Central Valley Domestic and Commercial Salt Load by Basin, 2007.

County	Basin	July 1, 2005	2007 Population	Water Use gal/person/day	2005 Water Use (af/yr)	2007 Water Use (af/yr)	Inflow TDS (mg/l)	Incremental TDS (mg/l)*	Salt Load (tons/yr)
Amador	SAC	38,023	38,435		8,744	8,839	200	350	6,610
Butte	SAC	214,722	218,069		49,381	50,151	200	350	37,504
Colusa	SAC	21,275	21,951		4,893	5,048	200	350	3,775
El Dorado	SAC	175,525	178,674		40,367	41,091	200	350	30,729
Glenn	SAC	28,314	28,915		6,512	6,650	200	350	4,973
Lake	SAC	63,302	64,276		14,558	14,782	200	350	11,054
Lassen	SAC	35,740	36,375		8,219	8,365	200	350	6,256
Modoc	SAC	9,894	9,721		2,275	2,236	200	350	1,672
Nevada	SAC	99,236	99,766		22,822	22,944	200	350	17,158
Placer	SAC	313,133	324,495		72,014	74,627	200	350	55,808
Plumas	SAC	21,161	21,128		4,867	4,859	200	350	3,634
Sacramento	SAC	1,378,068	1,406,804		316,925	323,534	200	350	241,948
Shasta	SAC	178,898	181,401		41,143	41,718	200	350	31,198
Sierra	SAC	3,489	3,485		802	801	200	350	599
Solano	SAC	420,246	424,823		96,647	97,700	200	350	73,063
Sutter	SAC	90,206	93,919		20,745	21,599	200	350	16,153
Tehama	SAC	60,548	61,774		13,925	14,207	200	350	10,624
Yolo	SAC	188,788	193,983		43,417	44,612	200	350	33,362
Yuba	SAC	68,892	70,745		15,844	16,270	200	350	12,167
Basin Totals		3,409,460	3,478,739	205	784,100	800,033			598,287
Contra Costa	SJ	1,025,627	1,042,341		196,594	199,798	200	350	149,415
San Joaquin	SJ	662,008	679,687		126,895	130,284	200	350	97,430
Stanislaus	SJ	510,164	521,497		97,789	99,962	200	350	74,754
Merced	SJ	243,457	251,510		46,666	48,210	200	350	36,053
Madera	SJ	143,250	148,721		27,458	28,507	200	350	21,318
Tuolumne	SJ	57,176	57,223		10,960	10,969	200	350	8,203
Calaveras	SJ	45,272	46,028		8,678	8,823	200	350	6,598
Mariposa	SJ	18,045	18,254		3,459	3,499	200	350	2,617
Basin Totals		2,704,999	2,765,261	171	518,500	530,051			396,387
Fresno	TULAR	891,134	917,515		239,708	246,805	200	350	184,568
Kern	TULAR	768,928	801,648		206,836	215,637	200	350	161,260
Tulare	TULAR	415,820	429,006		111,853	115,399	200	350	86,299
Kings	TULAR	146,112	151,381		39,303	40,720	200	350	30,452
Basin Totals		2,221,994	2,299,550	240	597,700	618,562			462,578
Central Valley Totals		8,336,453	8,543,550	204	1,900,300	1,948,646			1,457,252

3.1.4 Industrial Salt Accumulations

Salt accumulations were estimated for four categories of manufacturing:

- Manufacturing other than food processing,
- Food processing other than fruit and vegetable, dairy, meat processing and wineries,
- Fruit and vegetable, dairy and meat processing, and Wineries.

The procedure for estimating salt loads is the same for all categories of dischargers. Manufacturing water use was estimated on the basis of gross sector sales (US Census of Manufacturing) and a discharge salt concentration of 550 ppm.

A total salt load of 282 thousand tons per year was estimated for manufacturing other than food processing (Table 3.1.3). About 47 percent of that is attributed to the San Joaquin Basin and only 23 percent is located in the Tulare Basin.

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Table 3.1.3. Central Valley Manufacturing Other than Food Processing Salt Load by Basin

County	Basin	NAICS 32-33 Sales (k)	Water Use (af/yr)	TDS (mg/l)	Incremental TDS (mg/l)*	Salt Load (tons/yr)
Amador	SAC	129,415	538	200	550	548
Butte	SAC	505,267	2,100	200	550	2,141
Colusa	SAC	228,592	950	200	550	969
El Dorado	SAC	967,122	4,019	200	550	4,098
Glenn	SAC	289,383	1,202	200	550	1,226
Lake	SAC	172,554	717	200	550	731
Lassen	SAC	86,277	359	200	550	366
Modoc	SAC	0	0	200	550	0
Nevada	SAC	399,853	1,662	200	550	1,694
Placer	SAC	2,999,601	12,464	200	550	12,711
Plumas	SAC	114,323	475	200	550	484
Sacramento	SAC	4,717,872	19,604	200	550	19,992
Shasta	SAC	597,203	2,482	200	550	2,531
Sierra	SAC	0	0	200	550	0
Solano	SAC	3,763,793	15,640	200	550	15,949
Sutter	SAC	308,298	1,281	200	550	1,306
Tehama	SAC	483,533	2,009	200	550	2,049
Yolo	SAC	890,337	3,700	200	550	3,773
Yuba	SAC	263,837	1,096	200	550	1,118
Basin Totals		16,917,260	84,600			71,686
Calaveras	SJ	43,138	179	200	550	183
Contra Costa	SJ	10,958,744	45,537	200	550	46,437
Madera	SJ	1,104,524	4,590	200	550	4,680
Mariposa	SJ	0	0	200	550	0
Merced	SJ	1,336,237	5,552	200	550	5,662
San Joaquin	SJ	3,964,886	16,475	200	550	16,801
Stanislaus	SJ	3,578,402	14,869	200	550	15,163
Tuolumne	SJ	210,631	875	200	550	893
Basin Totals		21,196,563	90,100			89,819
Fresno	TULARE	2,966,013	12,325	200	550	12,568
Kern	TULARE	2,538,011	10,546	200	550	10,755
Kings	TULARE	211,510	879	200	550	896
Tulare	TULARE	1,101,863	4,579	200	550	4,669
Basin Totals		6,817,397	66,400			28,888
Central Valley Totals		44,931,220	241,100			190,394

Total salt load for Central Valley food processing, other than fruit & vegetable, dairy, meat processing and wineries, was estimated to be 42 thousand tons. About 42 percent of this total is produced in the San Joaquin Basin.

Table 3.1.4. Central Valley Food Processing (Other than Fruit & Vegetable, Dairy, Meat Processing and Wineries) Salt Load by Basin.

County	Basin	Sales (k)	Water Use (af/yr)	TDS (mg/l)	Incremental TDS (mg/l)*	Salt Load (tons/yr)
Amador	SAC	0	0	200	550	0
Butte	SAC	102,912	428	200	550	436
Colusa	SAC	0	0	200	550	0
El Dorado	SAC	0	0	200	550	0
Glenn	SAC	0	0	200	550	0
Lake	SAC	0	0	200	550	0
Lassen	SAC	0	0	200	550	0
Modoc	SAC	0	0	200	550	0
Nevada	SAC	0	0	200	550	0
Placer	SAC	0	0	200	550	0
Plumas	SAC	0	0	200	550	0
Sacramento	SAC	1,132,450	4,706	200	550	4,799
Shasta	SAC	0	0	200	550	0
Sierra	SAC	0	0	200	550	0
Solano	SAC	583,750	2,426	200	550	2,474
Sutter	SAC	120,265	500	200	550	510
Tehama	SAC	0	0	200	550	0
Yolo	SAC	392,582	1,631	200	550	1,664
Yuba	SAC	0	0	200	550	0
Basin Totals		2,331,959	9,690			9,882
Calaveras	SJ	0	0	200	550	0
Contra Costa	SJ	557,132	2,315	200	550	2,361
Madera	SJ	0	0	200	550	0
Mariposa	SJ	0	0	200	550	0
Merced	SJ	252,136	1,048	200	550	1,068
San Joaquin	SJ	1,654,609	6,875	200	550	7,011
Stanislaus	SJ	1,697,223	7,052	200	550	7,192
Tuolumne	SJ	0	0	200	550	0
Basin Totals		4,161,100	17,291			17,632
Fresno	TULARE	1,071,909	4,454	200	550	4,542
Kern	TULARE	1,214,111	5,045	200	550	5,145
Kings	TULARE	456,161	1,895	200	550	1,933
Tulare	TULARE	629,548	2,616	200	550	2,668
Basin Totals		3,371,729	14,011			14,288
Central Valley Totals		9,864,789	40,991			41,802

Total salt load for Central Valley food fruit & vegetable processing dairies and meat processing was estimated to be 42 thousand tons. About 46 percent of this total is produced in the Tulare Basin.

Table 3.1.5. Central Valley Fruit & Vegetable, Dairy and Meat Processing Salt Load by Basin

Fruit & Vegetable, Dairy, Meat Processing (NAICS 3114, 3115, 3116)

County	Basin	NAICS 3114, 3115, 3116 Sales (k)	Water Use (af/yr)	TDS (mg/l)	Incremental TDS (mg/l)	Salt Load (tons/yr)
Amador	SAC	0	0	200	550	0
Butte	SAC	192,428	800	200	550	815
Colusa	SAC	0	0	200	550	0
El Dorado	SAC	0	0	200	550	0
Glenn	SAC	0	0	200	550	0
Lake	SAC	0	0	200	550	0
Lassen	SAC	0	0	200	550	0
Modoc	SAC	0	0	200	550	0
Nevada	SAC	0	0	200	550	0
Placer	SAC	0	0	200	550	0
Plumas	SAC	0	0	200	550	0
Sacrament	SAC	609,517	2,533	200	550	2,583
Shasta	SAC	0	0	200	550	0
Sierra	SAC	0	0	200	550	0
Solano	SAC	0	0	200	550	0
Sutter	SAC	308,298	1,281	200	550	1,306
Tehama	SAC	0	0	200	550	0
Yolo	SAC	0	0	200	550	0
Yuba	SAC	0	0	200	550	0
Basin Totals		1,110,243	4,613			4,705
Calaveras	SJ	0	0	200	550	0
Contra Cos	SJ	0	0	200	550	0
Madera	SJ	0	0	200	550	0
Mariposa	SJ	0	0	200	550	0
Merced	SJ	1,336,237	5,552	200	550	5,662
San Joaqui	SJ	862,225	3,583	200	550	3,654
Stanislaus	SJ	1,957,198	8,133	200	550	8,294
Tuolumne	SJ	0	0	200	550	0
Basin Totals		4,155,660	17,268			17,609
Fresno	TULARE	1,970,677	8,189	200	550	8,351
Kern	TULARE	0	0	200	550	0
Kings	TULARE	601,525	2,500	200	550	2,549
Tulare	TULARE	2,031,666	8,442	200	550	8,609
Basin Totals		4,603,868	19,131			19,509
Central Valley Totals		9,869,770	41,012			41,823

Total salt load for Central Valley wineries was estimated to be 8 thousand tons. About 64 percent of this total is produced in the San Joaquin Basin.

Table 3.1.6. Central Valley Winery Salt Load by Basin

County	Basin	NAICS 31213 Sales (k)	Water Use (af/yr)	TDS (mg/l)	Incremental TDS (mg/l)	Salt Load (tons/yr)
Amador	SAC	129,415	538	200	550	548
Butte	SAC		0	200	550	0
Colusa	SAC		0	200	550	0
El Dorado	SAC		0	200	550	0
Glenn	SAC		0	200	550	0
Lake	SAC	172,554	717	200	550	731
Lassen	SAC	86,277	359	200	550	366
Modoc	SAC		0	200	550	0
Nevada	SAC		0	200	550	0
Placer	SAC		0	200	550	0
Plumas	SAC		0	200	550	0
Sacramento	SAC		0	200	550	0
Shasta	SAC		0	200	550	0
Sierra	SAC		0	200	550	0
Solano	SAC		0	200	550	0
Sutter	SAC		0	200	550	0
Tehama	SAC		0	200	550	0
Yolo	SAC	86,277	359	200	550	366
Yuba	SAC		0	200	550	0
Basin Totals		474,523	1,972			2,011
Calaveras	SJ	43,138	179	200	550	183
Contra Costa	SJ		0	200	550	0
Madera	SJ	301,969	1,255	200	550	1,280
Mariposa	SJ		0	200	550	0
Merced	SJ		0	200	550	0
San Joaquin	SJ	776,493	3,227	200	550	3,290
Stanislaus	SJ	129,415	538	200	550	548
Tuolumne	SJ		0	200	550	0
Basin Totals		1,251,016	5,198			5,301
Fresno	TULARE	568	2	200	550	2
Kern	TULARE	129,415	538	200	550	548
Kings	TULARE		0	200	550	0
Tulare	TULARE	86,277	359	200	550	366
Basin Totals		216,261	899			916
Central Valley Totals		1,941,799	8,069			8,228

The total industrial salt load for the Central Valley was estimated at 282 thousand tons. About 46 percent originates from the San Joaquin Basin and only 22 percent from the Tulare Basin.

Table 3.1.7. Total Central Valley Industrial Salt Load by Basin

County	Basin	Total Industry Salt Load (tons/yr)
Amador	SAC	1,097
Butte	SAC	3,393
Colusa	SAC	969
El Dorado	SAC	4,098
Glenn	SAC	1,226
Lake	SAC	1,462
Lassen	SAC	731
Modoc	SAC	0
Nevada	SAC	1,694
Placer	SAC	12,711
Plumas	SAC	484
Sacramento	SAC	27,373
Shasta	SAC	2,531
Sierra	SAC	0
Solano	SAC	18,422
Sutter	SAC	3,122
Tehama	SAC	2,049
Yolo	SAC	5,802
Yuba	SAC	1,118
Basin Totals		88,283
Calaveras	SJ	366
Contra Costa	SJ	48,798
Madera	SJ	5,960
Mariposa	SJ	0
Merced	SJ	12,393
San Joaquin	SJ	30,756
Stanislaus	SJ	31,197
Tuolumne	SJ	893
Basin Totals		130,362
Fresno	TULARE	25,464
Kern	TULARE	16,448
Kings	TULARE	5,378
Tulare	TULARE	16,311
Basin Totals		63,601
Central Valley Totals		282,246

3.1.5 Confined Animal Salt Accumulations

The total confined animal salt load for the Central Valley was estimated at 406 thousand tons. About 60 percent originates from the Tulare Basin and only 4 percent from the Sacramento Basin.

Table 3.1.8.Total Central Valley Confined Animal Salt Load by Basin

Confined Animal Feeding Operations-Animal Numbers, 2002*						Salt Load (tons/yr)				
County	Basin	Poultry	Hogs	Dairy	Cattle on Feed	Poultry	Hogs	Dairy	Cattle on Feed	Total
Amador	SAC	723	94	20	482	0	4	4	77	86
Butte	SAC	4,583	6,961	1,261	174	3	297	269	28	597
Colusa	SAC	133	275			0	12	0	0	12
El Dorado	SAC	2,644	363	9	77	2	16	2	12	31
Glenn	SAC	780	1,692	21,325		0	72	4,553	0	4,626
Lake	SAC	6,198	242	4	13	4	10	1	2	17
Lassen	SAC	495	488	38		0	21	8	0	29
Modoc	SAC	389	181	14	180	0	8	3	29	40
Nevada	SAC	1,825	139	108	96	1	6	23	15	46
Placer	SAC	6,208	500		283	4	21	0	45	71
Plumas	SAC	594	153	840		0	7	179	0	186
Sacramento	SAC	490,214	1,797	18,133	298	314	77	3,871	48	4,310
Shasta	SAC	3,014	429	562	173	2	18	120	28	168
Sierra	SAC	52				0	0	0	0	0
Solano	SAC	22,786	294	3,812	1,380	15	13	814	221	1,062
Sutter	SAC	1,431	308	524		1	13	112	0	126
Tehama	SAC	2,846	649	5,489		2	28	1,172	0	1,201
Yolo	SAC	968	1,508	3,274		1	64	699	0	764
Yuba	SAC	1,866	804	3,032		1	34	647	0	683
Basin Totals		547,749	16,877	58,445	3,156	351	721	12,478	505	14,055
Calaveras	SJ	1,356	175	222	343	1	7	47	55	111
Contra Costa	SJ	3,306	137		66	2	6	0	11	19
Madera	SJ	1,239,441	593	69,345	2,500	794	25	14,805	400	16,025
Mariposa	SJ	551		245	375	0	0	52	60	113
Merced	SJ	6,281,469	8,197	267,888	928	4,023	350	57,194	149	61,716
San Joaquin	SJ	3,261,207	2,156	106,077	1,819	2,089	92	22,647	291	25,120
Stanislaus	SJ	3,693,799	23,172	199,415	3,020	2,366	989	42,575	484	46,414
Tuolumne	SJ	650,082	69	108	118	416	3	23	19	461
Basin Totals		15,131,211	34,499	643,300	9,169	9,692	1,473	137,345	1,468	149,977
Fresno	TULARE	10,972,535	7,830	125,902	150,000	7,028	334	26,880	24,019	58,261
Kern	TULARE	130	2,731	150,190	28,000	0	117	32,066	4,484	36,666
Kings	TULARE	1,012,531		160,194	32	649	0	34,201	5	34,855
Tulare	TULARE	2,295,329	116,500	494,102	197	1,470	4,975	105,491	32	111,967
Basin Totals		14,280,525	127,061	930,388	178,229	9,147	5,426	198,638	28,539	241,749
Central Valley Totals		29,959,485	178,437	1,632,133	190,554	19,189	7,619	348,460	30,512	405,781

3.1.6 Projected Agricultural Salt Accumulations

Projections of salt loads to the San Joaquin Valley from 2005 to 2035 are illustrated in Table 3.1.9. For year 2005, about 45% of the salt load in the San Joaquin basin (or 396,387 tons/yr) originate from municipal and commercial wastewater discharges. This proportion remains fairly constant over time. In 2005 the second largest contributor to the salt load is irrigated agriculture with 202,500 tons/yr. Confined animal operations (17.06%) and industrial processes (14.83%) follow. By 2030 this set of contributions to accumulated salt loads shifts slightly with increases in the share from industrial processes (18.95%) and municipal and commercial sources.

In the Tulare basin, in contrast, agricultural salt loads are more important relative to industrial and municipal sources. Approximately 540,000 tons of salt originate from confined animal and irrigated crop operations in Tulare. This accounts for half of the total salt accumulation in the basin, followed by municipal and industrial loads (43.42%) and industrial processes (5.97%). By 2030 the contributions by source do not change as abruptly as for municipal and commercial, however share of annual accumulated salt loads from industrial operations increases by nearly 40%.

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Estimates of irrigated agriculture salt loads south of the Sacramento Basin follow previous studies by Orlob, (1991)and more recently by Shoups et al. (2005). According to these studies, the estimated net salt accumulation is about 466,000 tons per year and had been constant for the period 1950-89 (Orlob, 1991). This figure is obtained as the difference between accretion and excretion rates in the basin. A slightly greater amount is suggested by Shoups et al. (2005) for the period 1950-1997, which corresponds to total dissolved solids in groundwater.

3.1.7 Projected Central Valley Salt Accumulations

Central Valley salt loads were projected to 2030 using REMI projections of sector sales and the annual base salt loads presented above. Table 3.1.9 presents the estimated levels, changes and percent changes in salt loads for the three Basins and sectors. An increase of 9 percent in the total salt load is projected for the Sacramento Basin as compared to 7.5 percent for the San Joaquin Basin and 5 percent for the Tulare Basin.

Substantial increases in domestic and commercial salt loads are projected for the Central Valley. The largest is 243 thousand tons from the Sacramento Basin. The San Joaquin Basin is projected to increase by 152 thousand tons and the Tulare by 143 thousand tons.

Rather large increases are projected for other manufacturing sectors located in the Central Valley. The Sacramento Basin amount is projected to increase by 183 thousand tons by 2030.

The Tulare Basin confined animal salt load is slated for a 53 percent or 128 thousand ton increase. The San Joaquin Basin is projected to increase by 77 thousand tons.

Table 3.1.9. Salt Load Projections by Source in California's Central Valley

Basin and Sector	2005	Contribution %	2030	Contribution %
Sacramento Basin				
Municipal & Commercial	598,287	85.39%	840,864	73.55%
Industrial				
Wineries	2,011	0.29%	2,630	0.23%
Food Processing	14,586	2.08%	23,548	2.06%
Other Manufacturing	71,686	10.23%	255,018	22.31%
Total Industrial	88,283	12.60%	281,196	24.60%
Agriculture				
Confined Animals	14,055	2.01%	21,146	1.85%
Irrigated Crops	0	0.00%	0	0.00%
Total Agriculture	14,055	2.01%	21,146	1.85%
Total Sacramento Basin	700,625	100.00%	1,143,206	100.00%
San Joaquin Basin				
Municipal & Commercial	396,387	45.08%	548,810	45.46%
Industrial				
Wineries	5,301	0.60%	7,094	0.59%
Food Processing	35,242	4.01%	57,049	4.73%
Other Manufacturing	89,819	10.22%	164,641	13.64%
Total Industrial	130,362	14.83%	228,784	18.95%
Agriculture		0.00%		
Confined Animals	149,977	17.06%	227,182	18.82%
Irrigated Crops	202,500	23.03%	202,500	16.77%
Total Agriculture	352,477	40.09%	429,682	35.59%
Total San Joaquin Basin	879,227	100.00%	1,207,276	100.00%
Tulare Basin				
Municipal & Commercial	462,578	43.42%	605,647	43.67%
Industrial				
Wineries	916	0.09%	1,257	0.09%
Food Processing	33,796	3.17%	53,574	3.86%
Other Manufacturing	28,888	2.71%	59,504	4.29%
Total Industrial	63,601	5.97%	114,335	8.24%
Agriculture				
Confined Animals	241,749	22.69%	369,484	26.64%
Irrigated Crops	297,500	27.92%	297,500	21.45%
Total Agriculture	539,249	50.61%	666,984	48.09%
Total Tulare Basin	1,065,428	100.00%	1,386,966	100.00%
Central Valley Total Salt Load	2,645,279		3,737,448	

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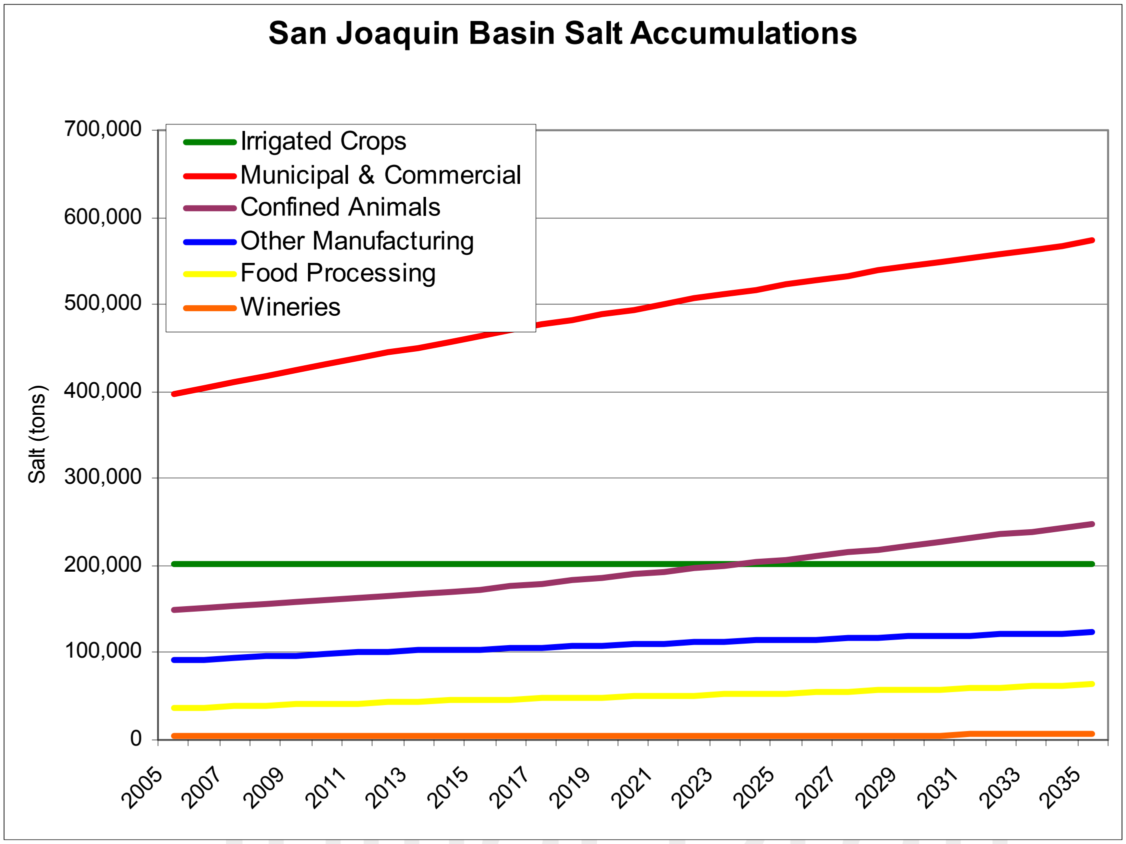

Figure 3.1.1 Projections of Average Annual Load by Source in the San Joaquin Basin

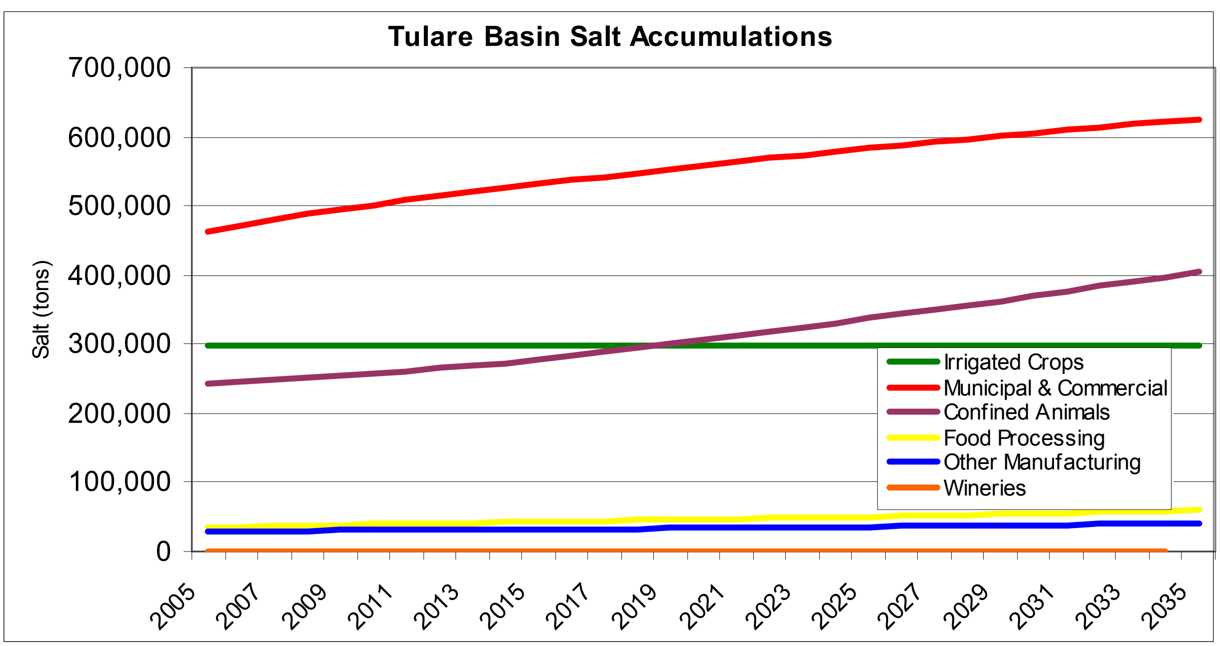

Figure 3.1.2. Projections of Average Annual Load by Source in the Tulare Basin

The following pie charts show the difference in contributions to total average salt load for each basin. Salt load in Sacramento basin is dominated by municipal wastewater. The 2% share of agriculture is due to livestock operations. As mentioned, municipal wastewater and agricultural salt load share will be reduced relative to industrial salt load by year 2030 (Table 3.1.9).

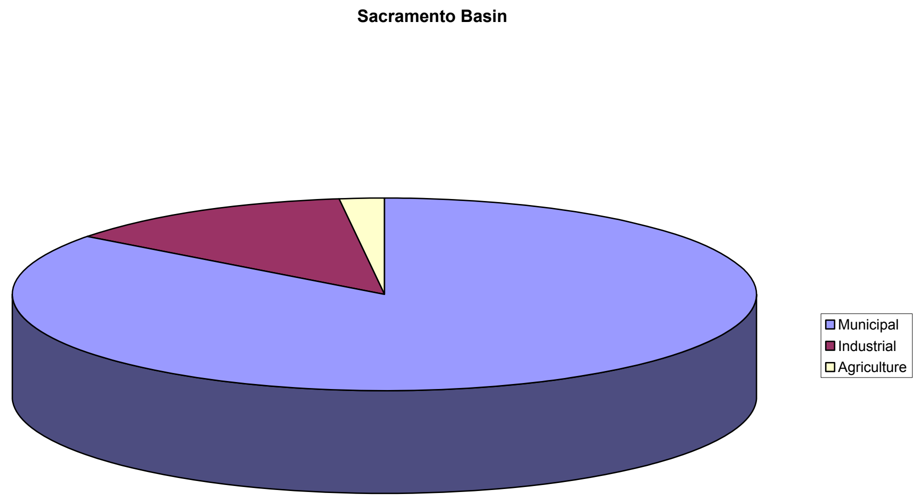

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Figure 3.1.3. Share of salt load per year in the Sacramento Valley in 2005.

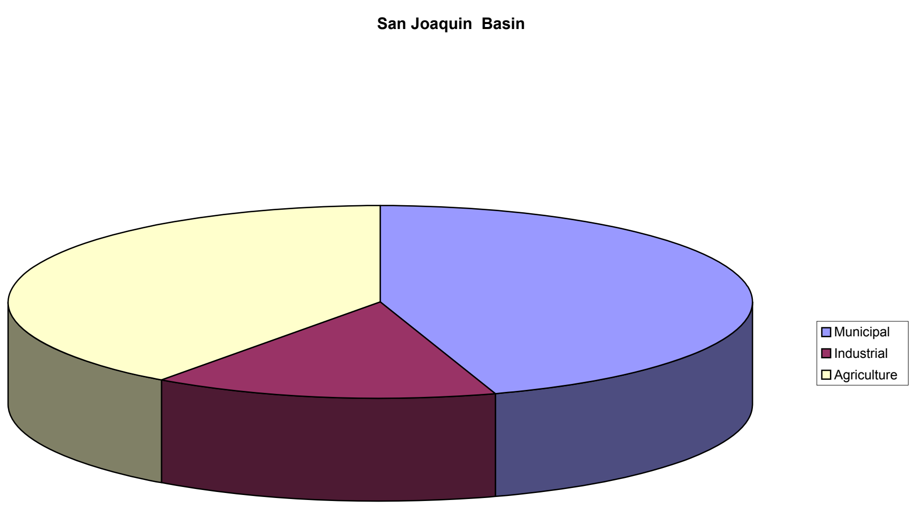

Figure 3.1.4. Share of salt load per year in the San Joaquin Valley in 2005.

Municipal and agriculture are the two most important sources of salt in the San Joaquin Valley in 2005 (Figure 3.1.4). By year 2030, industrial and municipal sources increase their share relative to agriculture. Within agriculture, confined animal operation increases its share with respect to irrigated agriculture. Finally, Tulare's agriculture is the economic activity that brings more salt to the basin, followed by Municipal uses ().

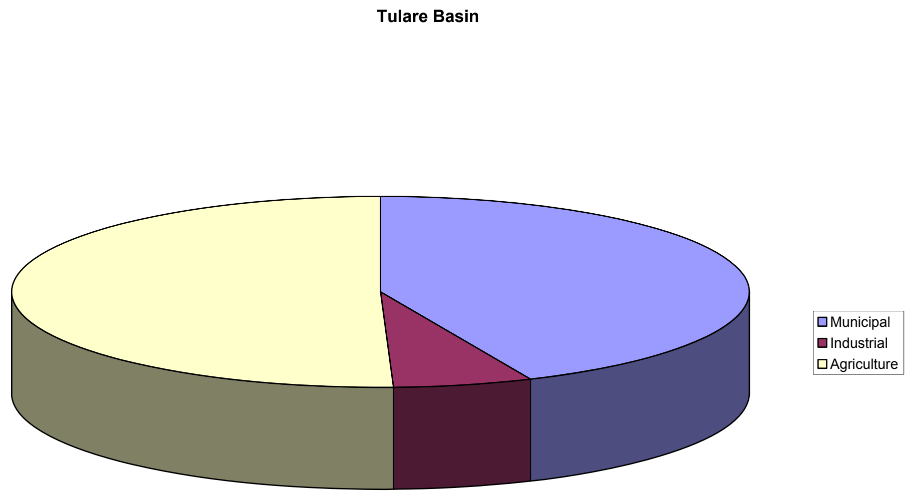

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Figure 3.1.5. Share of salt load per year in the San Joaquin Valley in 2005.

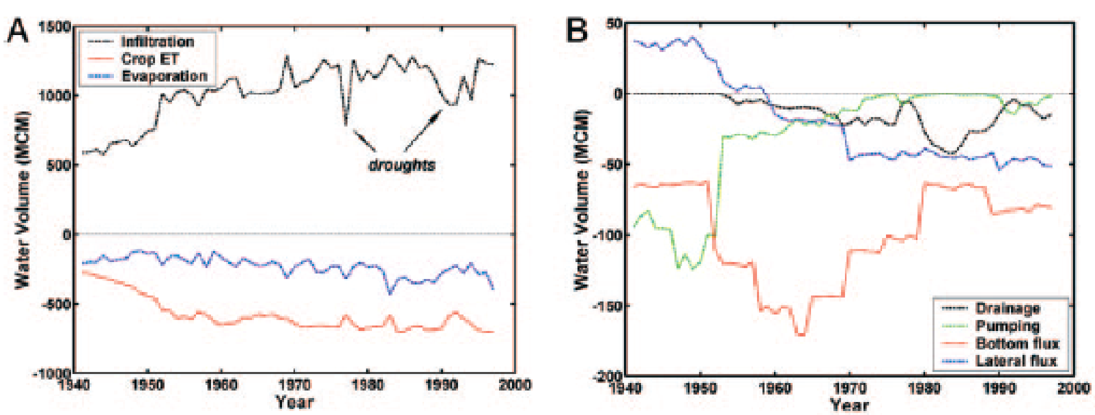

Figure 3.1.6. Hydrodynamics in Shoups et al. (2005). Left: water volume through infilgtration, crop evapotranspiration and evaporation. Right: Water volume flow per source an sink.

The hydrodynamic simulations in Shoups et al. (2005) suggest that the sustainability of irrigated agriculture in the Central Valley is jeopardized by the rise in the water table and salinization of both shallow groundwater and the confined aquifer. Substitution of groundwater for surface water from the state water project and the central valley project after the 1950's causes a downward trend on soil salinization (left panelFigure 3.1.7) A reversal of this trend is observed after the 1970s when the water table starts to raise. The slope of the total dissolved salts (right panel,Figure 3.1.7) is according to Shoups et al. (2005) close to half a million tons per year due mainly to gypsum dissolution. The total inflows of salt remain more or less constant after 1970s, as salt loads by irrigation are cancelled out by lateral flows to the San Joaquin valley and deep percolation through the Corcoran clay right above the confined aquifer.

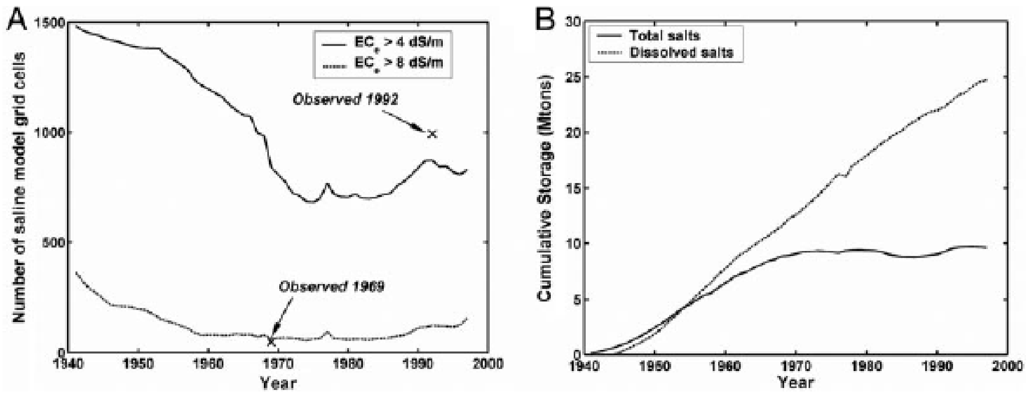

Figure 3.1.7. Left: number of saline model grid cells over time. Right: cumulative salt storage. From Shoups et al (2005).

Salinity in the root zone and depth of the shallow groundwater table have been found to be closely related. Using Shoups' (2004) simulation on the number of cells with a shallow groundwater table (< 2m), it is estimated that the saline soil area will increase at a rate of 0.5% per year. Thus, a 12% increment in salinized soil would be expected by 2030.

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The *Rainbow Report* (San Joaquin Valley Drainage Program, 1990), on the other hand, suggests that by year 2040, the area with shallow groundwater table (less than 5ft) will be roughly 15.14% greater than area in year 2000. By 2030 then, salinized soil area could be roughly 9% higher than in 2005. SWAP model runs of this study use a range between 7% and 12% area increment in saline soil (Figure 3.1.8).

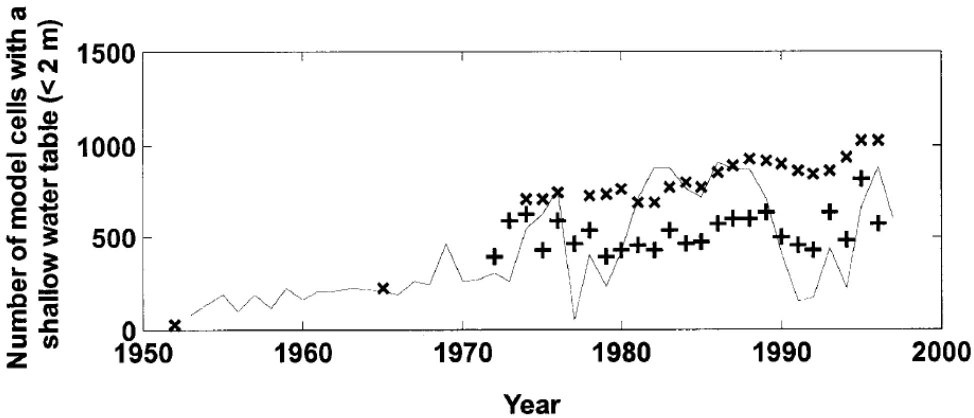

Figure 3.1.8. Relative change in the shallow groundwater table (after Shoups 2004).

3.1.8 Salinity accumulation model

For the Central Valley, it was assumed that for the year 2030 the non-saline cultivated area of each CVPM will decrease by seven percent. However this seven percent will turn into a saline zone. As mentioned above, five CVPMs were considered, namely 10, 14, 15, 19 and 21. Within each of these CVPMs there are six salinity zones as seen in the previous section. The acres included in the seven percent are distributed among the other salinity zones (0-2000 µS/cm, 2000-4000 µS/cm, 4000-10,000 µS/cm, 10,000-20,000 µS/cm and more than 20,000 µS/cm). Thus if a CVPM's non-saline 7-percent land loss is 100 acres, the saline zones A, B, C, D and E would increase their area by 50, 30, 10, 10 and zero acres respectively. There is an underlying assumption that acreage in the most saline zone does not increase. This assumption is needed because the yield reduction for hypersaline soils would be substantial and may introduce numerical issues. Area under this condition is at most 2.8 percent of total agricultural land use in a CVPM. The same assumption is repeated when a 12-percent increase in saline soil is assumed.

Table 3.1.10. Changes in salnity zone area.

Zone	Percent Change
0-2000 µS/cm	50
2000-4000 µS/cm	30
4000-10000 µS/cm	10
10000-20000 µS/cm	10
20000- µS/cm	0

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3.2 Urban Salinity Costs

This section measures the effects of increasing salinity on urban users by considering the effects on residential users. The report follows the methodology of Metropolitan Water District of Southern California's Salinity Management Report (MWD 1999) and the Hilmar Supplemental Environmental Project (Sunding, et al., 2006).

As water quality decreases the effect on urban users is seen through two effects: taste and capital depreciation. Salinity leads to accelerated depreciation of water fixtures as pipes and household appliances are required to be replaced more frequently. This is the capital depreciation effect. Additionally, higher salinity leads to investment in water softeners and water filtration devices to offset the poor taste, the taste effect.

This report assumes that the effect of increasing salinity is uniform across all residential users. Since the costs of salinity are going to be quantified as either resulting from taste changes or capital depreciation it is reasonable to assume the single family attached and detached homes will be affected the same. Multi-family dwelling units, such as apartment complexes, are also assumed to be affected in the same way as single family homes. For these dwellings capital depreciation and taste will be costs to the owners of the units instead of the families. It is reasonable to assume that these costs are identical to those of the single family homes.

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3.2.1 Literature on Household Costs of Increasing Salinity: A Brief Review

This section thus instead provides a brief review of the literature on the cost of increasing salinity in the household water supply.

To determine the costs salinity directly imposed on households, Ragan et al. (1993) sent surveys to households, plumbers, and appliance repair persons. The sample included 681 households in southeast Colorado, located in the Arkansas River Basin. Salinity levels of tap water in this area varied from 100 to 3,500 mg/L. Tap water in the San Joaquin Valley for which data is available ranges from about 300 mg/L to 1,800 mg/L. Tap water in rural areas may contain higher levels of salinity since, in these areas, tap water often comes from unmonitored wells.

Their household survey asked questions about the costs, repairs, and replacements of water using appliances, the service life and costs of fixtures and plumping, vehicle maintenance, laundry habits, and bottled water usage. They also ask households how much they value improving water quality up to the point where their appliances, plumbing, and vehicles would not experience scaling or corroding and their tap water would not have a poor taste. The surveys sent to plumbers and appliance repair persons contained questions concerning the costs of repairs and the frequency with which repairs were needed.

By combining the survey data with data on salinity levels, they estimate the effect salinity has on the lifespan of household products. They employ models from accelerated testing methods. These methods are generally used in laboratories, where environmental factors lead to accelerated failure of the product being tested. Here, the researchers treat the various levels of salinity like the various levels of the acceleration-inducing factors. With the costs of repairs obtained from all three types of surveys, Ragan et al compute the costs of shorter product life spans.

Their Table 22 has been reproduced below as Table 3.2.1. It shows the costs per year a household faces for a given level of salinity, relative to a salinity level of 0 mg/L, or the complete absence of salts in the water. They compute costs for two distributions of household appliances, fixtures, plumbing, and vehicles. The first assumes all products are new. Since newer products are generally of higher quality than their corresponding older version, the costs to a household with all new appliances is less than that for a household whose appliances are at various ages. The latter scenario is represented by the steady state distribution.

Table 3.2.1. Total excess cost per household for appliance replacement at eight percent discount rate and its standard error as functions of salinity under "all new" and steady-state age distributions

	"All New" Age Distribution		Steady-state Age Distribution	
Salinity (mg/l)	Cost ($/yr)	Std. Error ($/yr)	Cost ($/yr)	Std. Error ($/yr)
100	4.47	3.39	5.43	3.69
200	9.23	5.22	11.17	4.69
300	13.71	6.10	16.59	5.45
400	17.59	6.64	21.32	5.98
500	20.76	6.97	25.26	6.28
600	23.29	7.17	28.48	6.48
700	25.32	7.32	31.13	6.62
800	26.98	7.43	33.33	6.72
900	28.39	7.54	35.21	6.81
1000	29.61	7.64	36.86	6.88
1200	31.74	7.87	39.68	7.01
1400	33.64	8.11	42.12	7.14
1600	35.44	8.36	44.35	7.28
1800	37.20	8.61	46.45	7.41
2000	38.96	8.86	48.50	7.55
2500	43.46	9.48	53.59	7.91
3000	48.26	10.11	58.88	8.31
3500	53.45	10.74	64.53	8.75
4000	59.11	11.40	70.63	9.23

[a] Reproduced from Ragan et al (1993)

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We can see how much salinity in the San Joaquin Valley costs households by applying these costs to households with the mean, median, minimum, and maximum salinity levels found in the Valley (Table 3.2.2).

Table 3.2.2. Total excess cost per household for appliance replacement for representative households in the San Joaquin Valley.

Type of household	"All New" Age Distribution		Steady-state Age Distribution	
	Cost ($/yr)	Std. Error ($/yr)	Cost ($/yr)	Std. Error ($/yr)
Minimum Salinity (297.3 mg/L)	13.71	6.10	16.59	5.45
Median Salinity (486.5 mg/L)	20.76	6.97	25.26	6.28
Mean Salinity (624.7 mg/L)	23.29	7.17	28.48	6.48
Maximum Salinity (1743.2 mg/L)	37.20	8.61	46.45	7.41

Although they ask about households' willingness to pay to reduce salinity levels, they do very little analysis of this data. Their graph, however does reveal an increasing relationship between salinity and willingness to pay.

Coe (1982) looked at cost effects of overall water quality and included total dissolved solids among the components of water quality. He sent 3,000 surveys to households in Los Angeles and Riverside Counties. Tap water salinity ranges from 228 to 749 mg/l in these areas. The survey asked about household characteristics, water softening practices, consumption and costs of bottled water, uses of soaps and detergents, appliance life spans, and the damage and replacement of fabrics and fixtures. The survey also asks about the household's additional willingness to pay for "top water quality" that would not cause damage or require bottled water use.

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Looking only at correlation coefficients, they find a negative correlation between total dissolved solids (TDS) and the life of water heaters, washing machines, faucets, galvanized pipes, and copper pipes. They find no correlation between TDS and the life span of toilet mechanisms or willingness to pay for improved water quality.

They employ multiple regression analysis in models where household costs are assumed to be linearly related to various water quality levels. They find the coefficient on TDS is positive in models for the costs of water heaters, costs of water basins, costs of sinks, and costs of laundry tubs. The coefficient on TDS is negative in the model of costs of home softening. It is not significant in models of the costs of soap, bottled water, filters, washing machines, toilet mechanisms, pipes, faucets, toilets, or clothes. Assuming total costs to the household are linear in TDS, a salinity increase of 100 mg/L increases monthly costs by $4.70.

They find that the additional amount households are willing to pay for improved water quality ranges from $3.21 to $9.39 in 2005 dollars. However, this represents an upper bound for salinity willingness to pay with respect to household water-related expenses since this survey asks about water quality in general instead of salinity specifically.

As part of the Metropolitan Water District of Southern California's 1999 Salinity Management Plan, Bookman-Edmonston Engineering, Inc., or BEEI (, 1999 #64} reviewed and revised previous studies of the impact of salinity to estimate the costs of salinity to households in southern California. Previous work included Andersen and

Kleinman (1978), D'Arge and Eubanks (1978), Milliken-Chapman (Lohman and Milliken, 1988), and the above mentioned Ragan (1993). Since these studies were undertaken, prices, construction materials, technology, water quality, and demographics have changed, and this report attempts to account for those changes.

BEEI concluded that salinity most likely does not negatively impact copper water supply pipes, waste water pipes, toilet flushing mechanisms, or motor vehicle cooling systems. The relationship between salinity and the lifespan of various household items is shown in Table 3.2.3 below.

Table 3.2.3. Economic Impacts of Reduced Life of Water Using Appliances and Plumbing (1996 Price Level).

Appliance/Plumbing Item	Percent of Residences with Appliance	Replacement Cost	Life Span in Years as a Function of TDS in mg/L
Galvanized steel water supply pipes[1]	13%	\$2,600	$12+\exp(3.4 - 0.0018\ TDS)$
Water Heater	97%	\$300	$14.63 - 0.013\ TDS + 0.689\ (10^{-5}) TDS^2 - 0.11\ (10^{-8})\ TDS^3$
Faucet	100%	\$442	$11.55 - 3.05\ (10^{-3})\ TDS$
Garbage Disposal	75%	\$120	$9.23 - 3.87\ (10^{-3})\ TDS + 1.13\ (10^{-6})\ TDS^2$
Washing Machine	67%	\$425	$14.42 - 0.011\ TDS + 4.6\ (10^{-5})\ TDS^2$
Dishwasher	51%	\$450	$14.42 - 0.011\ TDS + 4.6\ (10^{-5})\ TDS^2$

[1]Equation from Tihansky (1974)

[a] Reproduced from Bookman-Edmonston Engineering, Inc. (1999)

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Using the formulas developed by BEEI, we can derive the lifespan of appliances for representative households in the San Joaquin Valley (Table 3.2.4). The lifespan of galvanized steel water supply pipes is more than cut in half as salinity moves from its lowest known level to its highest known level. Water heater lifespan decreases by 37%, faucet lifespan by 42%, and garbage disposal lifespan by 28% over the same salinity range. The results for washing machine and dishwasher lifespans indicate an increase in lifespan as salinity increases, suggesting that the BEEI equations are not well suited for the range of salinity change in the present study.

Table 3.2.4. Lifespan of household appliances for representative households in the San Joaquin Valley.

	Life Span in Years as a Function of TDS in mg/L			
Appliance/Plumbing Item	Minimum Salinity (297.3 mg/L)	Median Salinity (486.5 mg/L)	Mean Salinity (624.7 mg/L)	Maximum Salinity (1743.2 mg/L)
Galvanized steel water supply pipes	29.5	24.5	21.7	13.3
Water Heater	11.3	9.8	8.9	7.1
Faucet	10.6	10.1	9.6	6.2
Garbage Disposal	8.2	7.6	7.3	5.9
Washing Machine [a]	7.1	20.0	25.5	135.0
Dishwasher [a]	7.1	20.0	25.5	135.0

[a] Counterintuitively, lifespan increases with increased salinity, suggesting that these BEEI equations are not well suited for this application.

Looking at previous studies, Bruvold (1976), Black & Veatch (1967), Howson (1962), Ragan (1993), and OCWD (1972), involving water softeners, BEEI attempts to adjust these older studies from different locations to current conditions in southern California. Further data collection was undertaken by M. Cubed and Freeman-Sullivan Co. and resulted in the creation of the cost models shown below (Table 3.2.5).

Similarly, BEEI looked at previous studies of “dispensed water” or bottled water purchases and filtration systems. Bruvold (1976 and 1990) find a positive relationship between TDS and purchased water and water filtration. Additional surveys were conducted to update the available data. This new data also revealed a positive relationship between TDS and dispensed water purchases and home water filtration systems (Table 3.2.5).

Table 3.2.5. Economic Impacts of Avoidance of Salinity Impacts by Purchase of Dispensed Water, Home Filtration Systems, and Water Softeners (1996 Price Level)[a]

Avoidance Method	Annual Cost per Household as Function of TDS [($/year)/(mg/L)]
Home Water Softeners	$\$324 * [6.758 + 0.007 * TDS + (3.01(10^{-6}) * TDS^2) + (2.2(10^{-10}) * TDS^3)]$
Dispensed Water and Home Filtration System	$\$62 * (0.611 + 0.0000323 * TDS)$

[a] Reproduced from Bookman-Edmonston Engineering, Inc., 1999

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Again, we can apply these equations to households in the San Joaquin Valley (Table 3.2.6). Over the range of salinity levels found in the Valley, costs related to home water softener use increases by 221%, and the costs for bottled water and water filtration system purchases increase by 7.5%.

Table 3.2.6. Costs to representative households in the San Joaquin Valley as a function of total dissolved solids.

	Annual Cost per Household as Function of TDS			
Avoidance Method	Minimum Salinity (297.3 mg/L)	Median Salinity (486.5 mg/L)	Mean Salinity (624.7 mg/L)	Maximum Salinity (1743.2 mg/L)
Home Water Softeners	$2,951.94	$3,532.00	$4,004.37	$9,484.26
Dispensed Water and Home Filtration System	$38.48	$38.86	$39.13	$41.37

3.2.2 Quantifying Capital Depreciation

The most direct cost associated with salinity is the cost of capital depreciation of consumer water appliances. This report considers galvanized water pipes, water heaters, faucets, garbage grinders, dish washers, and clothes washers to be the appliances impacted by salinity. Functions are defined as in MWD 1999 and use updated parameters from Hilmar 2006.

Define $f(T)$ as the lifespan of an appliance as a function of salinity, T_0, T_1, where T is measured in TDS (mg/L) with 0,1 denoting base salinity TDS and TDS under hypothesized salinity increase, respectively. C is the cost of replacement, L is the annual loss for each appliance i.

$$L_i = C\left(\frac{1}{f(T_1)} - \frac{1}{f(T_0)}\right)$$

Where $L_k(T_0, T_1) = \sum_i p_i L_i$ is the overall annual cost of capital depreciation per household, where p_i is the percentage of residential customers that have appliance i.

Replacement Costs of Appliances are defined as in Hilmar (Hilmar 2006, section III.2). These estimates have been updated from the MWD 1999 study to reflect changes in replacement costs.

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In order to apply this methodology it is necessary to specify a base TDS and a TDS level under the increased salinity. MWD 1999 assumes a 100 TDS increase, Hilmar 2006 uses TDS of 500 mg/l as the base for agricultural analysis.

Most urban water is a mix of pumped groundwater and surface water. Schoups (2004) notes that pumped groundwater has a TDS concentration between 600 to 1320 mg/l and this is generally more saline than surface water (Shoups, 2004, p. 21)As a proxy for surface water salinity, the San Joaquin River has average TDS of 310 (Department of Water Resources). Using Modesto Irrigation District, Turlock ID, and Oakdale ID as a proxy for ground water/surface water mix, approximately 18% of total water supplied is groundwater and 82% from surface water, on average. Using the Schoups and DWR findings as estimates for average TDS of ground and surface water with 18% and 82% mixing, respectively, base TDS will be approximated by 427 mg/L. This is close to the assumed value in Hilmar 2006. Using the 30 year time trend of TDS (Schoups 2004, p.21) average annual TDS has increased by 40% over the period 1967-1997 using a simple linear approximation. Thus, a reasonable approximation for increased TDS is 598, which is in line with the assumed 100 TDS increase in MWD 1999 and Hilmar 2006.

For each of the specific appliances, impact functions are defined as follows (MWD 1999, Hilmar 2006). x is TDS, y is useful years.

$y = 12 + \exp(3.4 - .0018x)$ Galvanized Water Pipe

$y = 14.63 - .013x - .689(10^{-5})x^2 - .011(10^{-8})x^3$ Water Heater

$y = 11.55 - .00305x$ Faucets

$y = 9.23 - .00387x + 1.13(10^{-6})x^2$ Garbage Grinders

$y = 14.42 - .0114x + .46(10^{-5})x^2$ Clothes Washers

$y = 14.42 - .0114x + .46(10^{-5})x^2$ Dishwashers

Results of Capital Depreciation Costs are summarized in the Table 3.2.7 below

Table 3.2.7. Capital Depreciation Costs.

Urban Impacts from Capital Depreciation					
Appliance	Lifespan @ Base TDS	Lifespan @ High TDS	Replacement Cost	Annual Loss	% Users
Water Pipes (Galvanized)	25.89	20.50	12450	$126.51	5.00%
Water Heaters	7.81	2.12	750	$258.43	100.00%
Faucets	10.25	9.42	905	$7.81	100.00%
Garbage Grinders	7.78	7.07	205	$2.64	82.00%
Clothes Washers	10.39	8.69	575	$10.80	79.00%
Dishwashers	10.39	8.69	575	$10.80	77.00%
Total Impact per HH					**$291.58**

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3.2.3 Quantifying Changes in Taste

In addition to accelerated degradation of household appliances, urban users will invest in water softeners and dispensers as taste changes. The base and increased levels of TDS calculated above will be assumed for this component of urban cost as well.

To quantify the cost of changes in consumer taste, this report draws from the methodology in Hilmar 2006 (Hilmar 2006, section III.2). The functions that follow quantify the relationship between dispensed water and softener demand and TDS. Demand is expressed as a percentage of the total user base, thus multiplying this by the total population and annual cost yields annual cost of operation per household.

Formally, define C_s, C_d as annual per-capita operating costs for water softeners, water dispensers, respectively. p_s, p_d as the percent of households with water softeners, water dispensers. Then,

$L_T(T_0, T_1) = C_s\left[p_s(T_1) - p_s(T_0)\right] + C_d\left[p_d(T_1) - p_d(T_0)\right]$ is the total annual cost due to changes in taste.

The functions used to define these costs are presented as annual cost per household:

Water Softener: $434\left[6.758 + .007TDS + 3.01(10^{-6})TDS^2 + 2.2(10^{-10})TDS^3\right]$

Water Filtration: $79\left[.611 + 3.23(10^{-5})TDS\right]$

The results of this analysis are presented in the Table 3.2.8

Table 3.2.8. Changes in taste

Urban Impacts from Changes in Taste				
Treatment Option	Annual Operating Cost	% Users @ Base TDS	% Users @ Increase TDS	Annual Cost per HH
Water Softeners	$434.00	10.31%	13.21%	$1,256.6
Water Dispensers	$79.00	0.62%	0.63%	$0.70
Total Impact per HH				**$1,257.30**

3.2.4 Total Annual Effect

The urban costs of salinity are broken down into two separate effects. Therefore, the total annual costs per household are $L_k + L_T$, $1,548.89.

This report considers the economic impact in Tulare and San Joaquin Basin where, as stated above, the impacts are assumed to be uniform across single and multi-family homes. Using population projections from DWR (Department of Water Resources) and an average household size of 2.59 (Census 2000), the total impact is total annual costs per household multiplied by the number of households in the basin. These are projected out to 2030. This report finds total impacts until 2030 are $68,653,912 with an average yearly impact of $2,869,579.

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Table 3.2.9. Population, households and projected costs.

Projection Summary			
Year	**Population**	**Households**	**Cost**
2007	5,075.59	1,959.69	$2,463,914.79
2008	5,159.42	1,992.06	$2,504,611.02
2009	5,239.90	2,023.13	$2,543,679.55
2010	5,317.66	2,053.15	$2,581,426.22
2011	5,393.33	2,082.37	$2,618,157.83
2012	5,466.93	2,110.78	$2,653,888.94
2013	5,539.11	2,138.65	$2,688,927.31
2014	5,610.12	2,166.07	$2,723,399.18
2015	5,679.57	2,192.88	$2,757,113.75
2016	5,748.22	2,219.39	$2,790,439.48
2017	5,816.17	2,245.62	$2,823,422.98
2018	5,883.20	2,271.51	$2,855,965.20
2019	5,949.50	2,297.10	$2,888,146.74
2020	6,015.56	2,322.61	$2,920,217.12
2021	6,080.60	2,347.72	$2,951,788.94
2022	6,144.54	2,372.41	$2,982,829.69
2023	6,207.17	2,396.59	$3,013,234.50
2024	6,268.58	2,420.30	$3,043,045.18
2025	6,328.78	2,443.55	$3,072,270.32
2026	6,387.55	2,466.24	$3,100,799.38
2027	6,444.97	2,488.40	$3,128,669.69
2028	6,501.27	2,510.14	$3,156,000.67
2029	6,556.49	2,531.46	$3,182,810.77
2030	6,610.76	2,552.42	$3,209,153.39

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3.3 Salinity Effects on Industry

3.3.1 Industrial Salinity Costs

This section details the effects of increasing salinity on industrial users in regions impacted by salinity. As salinity increases the effect on industrial users is seen through accelerated depreciation of water fixtures and increased costs of treatment. This report assumes that salinity costs are uniform across all industrial users.

This report follows the methodology of “Assessing the Cost of Dryland Salinity to non-Agricultural Stakeholders – A Methodology Report” (Wilson, 2000). This report outlines a methodology for determining the number of industrial and commercial buildings in an urban center based on residential population and determines costs of salinity on a per building and per water used basis. This report relies on the estimates of cost per water usage.

The methodology adapted for this report relies on estimates of cost impacts due to increasing salinity for cooling tower operation, boiler operation, and process water treatment. Costs are reported in cost per acre foot per year due to a one mg/L increase in salinity.

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3.3.2 Increase in Operating Cost

Table 3.3.1 summarizes the increase in cost due to a one mg/L increase in salinity across the basin. This assumes uniformity of industry in the basin.

Table 3.3.1 Summary of cost increase.

Cost of 1 mg/L Increase in Salinity	
Business Item	**Cost per AF**
Cooling Tower Operation	$9.88
Boiler Operation	$5.38
Process Water Treatment	$6.15
Total Cost per AF	**$21.41**

3.3.3 Industrial Water Usage

Following the methodology used in the Urban Impacts section of this report, the annual water usage of Modesto ID and Turlock ID are used as an example. These areas are used as a proxy for saline regions throughout the valley. Total acre-feet of water per year in Modesto and Turlock Irrigation Districts are 78,802 and 26,790, respectively (Hilmar 2006). Of this 10,969 acre-feet per year are devoted to industrial users, combined. Usage is projected out until 2030 with average acre-foot usage per year of 11,120 for industrial users. The data are summarized in Table 3.3.2 below.

3.3.4 Impacts of Increasing Salinity

Under the same assumptions of the Urban Impacts section 3.2, this report assumes a TDS increase from 427 to 598 by 2030. This implies a 171 mg/L increase in salinity by 2030. Using a linear approximation, salinity is increasing by 7.125 mg/L per year. Projecting this increase out and multiplying by the water use projections outlined in Table 3.3.1, yields the cost impacts per year.

Using these estimates yields an average yearly impact of $21,295,894 per year. These projections are summarized in Table 3.3.2 below.

Table 3.3.2. Water use and estimated annual cost

Year	Water Use (AF)	Cost/Yr
2007	10,969	$1,673,076.03
2008	10,969	$3,346,152.06
2009	10,969	$5,019,228.09
2010	11,039	$6,735,011.87
2011	11,039	$8,418,764.83
2012	11,039	$10,102,517.80
2013	11,039	$11,786,270.76
2014	11,039	$13,470,023.73
2015	11,104	$15,243,005.39
2016	11,104	$16,936,672.65
2017	11,104	$18,630,339.92
2018	11,104	$20,324,007.18
2019	11,104	$22,017,674.45
2020	11,170	$23,852,277.28
2021	11,170	$25,556,011.37
2022	11,170	$27,259,745.46
2023	11,170	$28,963,479.55
2024	11,170	$30,667,213.64
2025	11,237	$32,565,115.46
2026	11,237	$34,279,068.91
2027	11,237	$35,993,022.35
2028	11,237	$37,706,975.80
2029	11,237	$39,420,929.24
2030	11,237	$41,134,882.69
Average		**$21,295,894.44**
Total		**$511,101,466.50**

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3.4 Salinity Effects on Food Processing

As in the Hilmar Supplemental Environmental Project, Sunding, Rubin, Berkman, 2006 report (referred to as Hilmar Report hereafter), the cost of salinity on food processing can be estimated through the impacts of regulation on the food processing industry. Increased salinity may result in increased regulation of the food processing industry leading to increased operating costs. This report considers the effect of a salinity reduction policy that would increase fixed and variable operating costs of processing plants. Under consideration are the long run costs of the food processors. It is assumed that the industry is competitive. Long run total variable cost is approximated by value added, the difference between total value of shipments and total cost of raw agricultural inputs.

The Hilmar report uses Stanislaus County as a proxy of the entire San Joaquin Valley, the representative area in the study. This report follows the steps of the Hilmar report closely, with more recent elasticity estimates from Green, Howitt, and Russo 2007. Additionally, this report considers fruit and vegetable processors. These updates are presented in bold.

In order to incorporate fruit and vegetable processors separately this report uses the elasticity estimates from Green, Howitt, and Russo 2007. According to the data collected in the Hilmar report there are 145 fruit and vegetable canneries in California (no attempt is made to differentiate between fruit and vegetable processors). There are 5 fruit and vegetable processors in Stanislaus County (the focus of this part of the report). This leads to a very rough estimate of .0344% regulated processors, this will be used to approximate "S", defined below.

In the analysis that follows the study area is Stanislaus Country, this area is being generalized to the San Joaquin Valley. These results can be easily generalized to represent any specific region in California.

3.4.1 Calculation of Elasticities

Existing literature was consulted to determine appropriate estimates of demand and supply elasticities. In general, the literature shows that market demand is generally inelastic whereas long run supply is more elastic resulting in consumers being expected to bear more of the costs. Elasticity estimates are summarized below in Table 3.4.1

Table 3.4.1. Estimated eslasticities.

Industry	Supply Elasticity	Demand Elasticity
Tomatoes	**0.69**	**-0.18**
Cheese	1.00	-0.50
Beef	3.24	-0.08
Pork	1.80	-0.08
Poultry	10.00	-0.50
Wine	1.00	-1.00
Fruit	**0.27**	**-0.50**
Vegetable	**0.69**	**-0.38**

Proceeding as in Hilmar, the residual demand elasticity is defined as the difference between total demand and total production by unregulated firms. If processors in the San Joaquin Valley are regulated and face increased costs, processors in other regions would be able to supply the market thereby leaving regulated processors with only residual demand. The elasticity corresponding to this residual demand is going to be more elastic.

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Define:
Q_R - Residual demand facing regulated producers
Q_T - Total demand in the market
Q_U - Supply from unregulated producers
ε_R - Residual demand elasticity
ε_T - Total demand elasticity
ε_U - Supply elasticity
s - Market share of producers affected by regulation

Residual demand is given as $Q_R = Q_T - Q_U$, the difference between total demand and what the unregulated producers supply.

$$\varepsilon_R = \left[\frac{1}{s}\varepsilon_T - \frac{(1-s)}{s}\varepsilon_U\right] = \frac{\varepsilon_T}{s} + \left(1 - \frac{1}{s}\right)\varepsilon_U$$

S is determined by considering the percent of processed food products (in each category) that come from the San Joaquin Valley relative to the total in California. It is assumed that the products of both regulated and unregulated producers are perfect substitutes. This is a key assumption because it says that food processors out of the regulated region are able to produce and ship the same goods as processors in the regulated region. Mathematically, it says that the total demand in the market is met by unregulated and regulated producers. Additionally, assume that regulated and unregulated producers face the same supply curve, thus the same elasticity of supply.

Table 3.4.2. Residual demand elasticities.

Industry	Residual Demand Elasticity
Tomatoes	**-3.09**
Cheese	-10.54
Beef	-600.40
Pork	-123.53
Poultry	-290.00
Wine	-46.62
Fruit	**-21.86**
Vegetable	**-30.34**

3.4.2 Calculation of Cost Share % and Market Transfer

Assume a one percent increase in food processing. This cost will either be passed forward to consumers in the form of higher prices or backward to farmers in the form of lower crop prices. The proportion of the burden that each market bears can be determined using elasticities.

Farm burden: $\frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$ Consumer burden: $1 - \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$

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The results are summarized in the Table 3.4.3 below.

In addition to determining who bears the burden of the cost increase, it is necessary to consider reduction in output. Following Hilmar, consider the market transfer effect which is the decrease in regional processed food production. Market transfer is calculated as the elasticity of supply times the farm (producer) cost share calculated above. This is because the producer cost share represents the proportion of a one percent increase in cost that goes to the producer. Results are summarized below.

Table 3.4.3. Procesor transfers percentages

Industry	Producer Share	Consumer Share	Mkt. Transfer %
Tomatoes	**0.82**	**0.18**	**0.56**
Cheese	0.91	0.09	0.91
Beef	0.99	0.01	3.22
Pork	0.99	0.01	1.77
Poultry	0.97	0.03	9.67
Wine	0.98	0.02	0.98
Fruit	**0.99**	**0.01**	**0.26**
Vegetable	**0.98**	**0.02**	**0.67**

3.4.3 Calculate Variable Cost per Unit

This measure is from the value added of the respective industry divided by the total quantity output. These measures are directly from the Hilmar report. Units are converted into tons for the analysis that follows. Fruit and vegetable are assumed to operate at costs identical to that of tomato processors in the region in this draft, research is in progress to determine more accurate estimates.

Table 3.4.4. Cost of compliance.

Industry	Variable Cost	Units	Variable Cost in Tons
Tomato	$45.00	Ton	$45
Cheese	$0.29	Lb	$580
Beef	$21.82	Cwt	$436
Pork	$15.53	Cwt	$311
Poultry	$38.88	Cwt	$778
Wine	$667.00	Ton	$667
Fruit	**$45.00**	**Ton**	**$45**
Vegetable	**$45.00**	**Ton**	**$45**

3.4.4 Calculate Treatment Costs per Unit

Continuing as in Hilmar, specify a target TDS level of salinity of 500 TDS. The average cost per ton of salt removal is calculated based on the engineering costs of various treatment alternatives.

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The cost per ton is determined as follows.
First, effluent per ton output and TDS are determined from in plant measures specific to each industry. Tons of Salt per ton output is calculated as: 1.1*(10^-9)*(Effluent per Ton output)*(TDS). Average cost per ton of salt removal is determined from engineering studies in the Hilmar Report according to the technique used. For each industry the salt removal technique considered is summarized below (Table 3.4.5).

Fruit and vegetable processors are assumed to use POTW's for treatment. Research is under way to determine more accurate methods. POTW treatment is assumed because it is an expensive alternative and serves as an interesting higher bound.

Table 3.4.5. Treatment methods.

Industry	Method
Tomato	In Plant Treatment
Cheese	EOP Effluent Treatment
Beef	EOP Effluent Treatment
Pork	EOP Effluent Treatment
Poultry	EOP Effluent Treatment
Wine	Supply Water Treatment
Fruit	**POTW**
Vegetable	**POTW**

This report assumes target TDS of 500 TDS and the percent salt removal required is calculated as 1 – (Target TDS / TDS). Finally, cost per ton is calculated as (tons salt per tons output)*(AC per tons salt removal)*(percent salt removal required). Fruit and vegetable are calculated based on the assumptions above.

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Table 3.4.6. Treatment costs.

Industry	Effluent per Ton Output	TDS	Tons of Salt per Ton Output	AC per Ton Salt Removal	Target TDS	% Salt Removal Required	Cost per Ton
Tomato	3482.20	531	0.0020	-$1,730.00	500	5.84%	-$0.21
Cheese	1362.60	1592	0.0024	$1,437.00	500	68.59%	$2.35
Beef	9311.10	604	0.0062	$3,626.00	500	17.22%	$3.86
Pork	9311.10	604	0.0062	$3,626.00	500	17.22%	$3.86
Poultry	6472.35	564	0.0040	$3,626.00	500	11.35%	$1.65
Wine	4258.13	1176	0.0055	$1,999.00	500	57.48%	$6.33
Fruit	**3482.20**	**642**	**0.0024**	**$5,397.00**	**500**	**22.21%**	**$2.94**
Vegetable	**3482.20**	**642**	**0.0024**	**$5,397.00**	**500**	**22.12%**	**$2.94**

3.4.5 Calculating the Cost and Market Impact

Using the above calculations the percent increase in variable cost is determined (variable cost plus cost per ton relative to variable cost). Next, to calculate output reduction the percentage increase in variable cost is multiplied by the market transfer percent, calculated in the previous section. The result is the percent reduction in regional output resulting form a percentage increase in variable cost according to the calculation above.

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Table 3.4.7. Changes in Processing Output.

Industry	% Increase In Variable Cost	% Output Reduction
Tomato	-0.46%	**-0.26%**
Cheese	0.41%	0.37%
Beef	0.89%	2.86%
Pork	1.24%	2.21%
Poultry	0.21%	2.05%
Wine	0.95%	0.93%
Fruit	**6.52%**	**1.71%**
Vegetable	**6.52%**	**4.40%**

Table 3.4.8. Changes in Processing Output by 2030.

	Processing	Costs	
			Output
			change
	% Change	Gross Output	$million
Tomato	0.26	1355	3.523
Wine	-0.93	1900	-17.67
Fruit& Veg	-3.1	2789	-86.459
		Total	-100.606
Beef & Pork	-2.86	1220	-34.892
Poultry	-2.05	576	-11.808
Cheese	-0.37	1001	-3.7037
		Total	-50.4037

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3.5 Confined Animal Feeding Operations

3.5.1 Introduction

Livestock and poultry production in the Central Valley of California is a major contributor to the agricultural economy of California. In 2005 gross returns to livestock and poultry production came to $9.7 billion (USDA-NASS 2006). Most of this production occurred in the San Joaquin River Basin and Tulare Basin. Livestock and livestock products in Tulare county alone accounted for 24 % of the gross value in this sector. Merced, Stanislaus, Fresno, and Kings Counties accounted for nearly 36% of the remaining gross value in this sector. In this same year, poultry and poultry products grossed nearly $1.2 billion. Thirty five percent of this production came from operations in Merced County. Fresno and Stanislaus Counties contributed another 45% of the gross value from poultry and poultry products. Perhaps more illustrative of the importance of the animal production in these basins to California's agricultural economy is the observation that milk and cream production in California ranked first among all agricultural products in California in 2005 totaling over $5.3 billion in gross value with Tulare, Merced, Stanislaus, Kings, and Kern Counties alone accounting for 60% of the gross value (USDA-ERS 2003).

The livestock and poultry production in the San Joaquin River Basin and Tulare Basin contribute significantly to the agricultural economy of California. However, this production also imports considerable volumes of salt. Feed is imported into the basins, bringing with it salts which are then excreted in animal manure. Further complicating the animal production, as noted in section 2.4, are federal regulations regarding manure nutrients, which will place greater controls on manure nutrients generated at concentrated animal feeding operations (CAFOs). To satisfy these controls (or constraints), CAFOs will most likely land apply the manure to balance the nutrient content of the manure with the nutrient demand of the crops grown on the land where manure is applied. Cropping patterns, however, will be affected by increasing salinity levels and as such will affect the ability of CAFOs to meet manure nutrient constraints. If we are to understand the future implications of increasing salinity levels on animal production in these basins and the effect of changes in animal production on salt loads, then it is crucial that we accurately model animal feeding operations and nutrient constraints in the Central Valley, while incorporating the interaction between increased salt loads and changes in cropping patterns so the effect of increased salinity levels can be disentangled from the effect of increased manure nutrientconstraints on CAFOs. In this section we develop a mathematical programming model to estimate the effect of increased salinity on animal feeding operations through the Sacramento River Basin, San Joaquin River Basin and the Tulare River Basin given the imposition of manure nutrient constraints.

3.5.2 Methods

The simulation model used to conduct the analysis employs an optimization technique based on the positive mathematical programming (PMP) methodology (Howitt, 1995).

The PMP method has been used extensively to study regional changes in agricultural production decisions and is well suited to the analysis proposed herein (see Draper, et al., 2003, Jenkins, et al., 2003, Johansson and Kaplan, 2004, Kaplan, et al., 2004, Key and Kaplan, 2007, Knapp, et al., 2003, Röhm and Dabbert, 2003) The PMP method calibrates the model to base year data without having to add constraints that cannot be justified by economic theory (Howitt, 1995). PMP takes advantage of the fact that it is easier to collect information about output and input levels at the farm level than information about production costs. The observed output and input levels result from a complicated decision process based in part on a cost function that is known to the farmer but difficult or impossible to observe directly. Some costs – perhaps associated with the environment, risk, or technology – may be hidden to the researcher even when a detailed survey instrument is available. PMP incorporates information about unobservable costs by using a quadratic cost function that approximates the true underlying cost function.

The model used to evaluate the economic consequences of manure nutrient standards and salinity effects on land availability is developed in three stages. First, a constrained linear programming model is used to derive dual values associated with the calibration constraints defined below. Second, the dual values are used to parameterize a calibrated quadratic objective function. Finally, the calibrated model is used for economic analysis by imposing nutrient constraints that change when salinity levels change due to unabated increases in salinity throughout the three basins.

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3.5.2.1 Linear program to calculate dual values

The linear objective is to maximize total net revenues:

(1) $$\max_{X1_{i,r}} \sum_r \sum_i X1_{i,r}\left(P_i Y_{i,r} - C_i\right),$$

where the product $X1_{i,r}Y_{i,r}$ is the level of each output i in region. $X1_{i,r}$ is the activity level and $Y_{i,r}$ the yield. The price for each output is denoted P_i and the cost of producing each output is $C_i = \sum_j A_{i,j} W_j$, where $A_{i,j}$ is the amount of input *j* required to produce a unit of output and W_j is the input price. The optimization is subject to J resource constraints:

(2) $$\sum_i A_{i,j} X1_{i,r} \le \sum_i A_{i,j} X0_{i,r}, \forall j, r$$

where $X0_{i,r}$ is the initial observed activity level, so that $\sum_i A_{i,j} X0_{i,r}$ is the initial level of input j.

Inputs include capital, feed, and animal head. Activities include dairy, hogs, cattle, broilers, and layers. Output includes, respectively, milk, average hog liveweight at slaughter, average cattle liveweight at slaughter, lbs of chicken meat, and eggs. The calibration constraints for all five activities are:

(3) $$X1_{i,r} \leq X0_{i,r}(1+\varepsilon_1), \forall i, r \quad \text{dual}: \hat{\lambda}_{i,r}$$

where ε_1 is a small perturbation (Howitt, 1995).

Data on prices P_i and W_i, the output levels $X0_{i,r}$, and most of the input-output coefficients $A_{I,j}$ come from the following sources: California Department of Food and Agriculture, the United States Department of Agriculture, Iowa State University Extension, University of California Cooperative Extension, the University of California, Davis, and the Western Beef Development Centre.

3.5.2.2 Estimation of calibrated quadratic cost function

Next we define quadratic total variable costs as $\frac{1}{2}\hat{Q}_{i,r} X2^2_{i,r}$, where

(5) $$\hat{Q}_{i,r} = \left(\hat{\lambda}_{i,r} + C_i\right) / X0_{i,r} \text{ for } i = dairy, hogs, cattle, broilers, layers$$

and $X2_{i,r}$ output in this stage. The objective in this stage is to maximize total net revenues:

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(6) $$\max_{X2_{i,r}} \sum_r \sum_i P_i X2_{i,r} - \frac{1}{2}\hat{Q}_{i,r} X2^2_{i,r}$$

subject to the resource constraints:

(7) $$\sum_i A_{i,j} X2_{i,r} \leq \sum_i A_{i,j} X0_{i,r}, \forall j, r$$

Solution of the non-linear optimization problem defined by (6) and (7) results in the initial output levels $X0_{I,r}$ (within a very small error). [5]

3.5.2.3 Nutrient Constraints

To evaluate the implications of meeting nutrient constraints, we simulate a constrained partial equilibrium, regional optimization model, which seeks to maximize profits from livestock, and poultry activites,

(8) $$\max_{X3_{i,r}} \sum_r \sum_i P3_i X3_{i,r} - \frac{1}{2}\hat{Q}_{i,r} X3^2_{i,r} - TC_r$$

subject to nutrient constraints

[5] The maximum percentage deviation between the base activity levels $X0_{i,r}$ and $X2_{i,r}$ was 1.19%. The median deviation was -0.10% and the average deviation was 0.023%.

(9) $$\sum_{i}(\theta_r \times man\_nut_{i,r,f}(X3_{i,r})) \leq \sum_{c}(WTAM \times Ag\_nut_{r,c,f}(Acre_{c,r})), \forall r, f \ .$$

where $X3_{i,r}$ is the optimal output level given the policy constraints. Off-farm manure transportation costs TC_r depend on technology choices that affect nutrient availability to the crop, and consequently the amount of land on which the manure must be spread. The nutrient constraint (eq. 9) explicitly requires the regional livestock and poultry operations to maintain nutrient balance through altering animal production. That is to say, within region r, the sum of each manure nutrient generated (man_nutr,j,f) by CAFOs must be less than or equal to a fixed proportion (WTAM) of the sum of the agronomic nutrient demand (Ag_nutr,c,f) for each cropping activity c, where f indexes nitrogen and phosphorus, respectively.6 The crops available for land application of manure include alfalfa, cotton, wheat, corn, pasture, sugar beets, and rice. The available demand for manure nutrients may be enhanced by increasing the willingness to accept manure rate (WTAM) or by increasing the agronomic nutrient demand through changes in cropping patterns. In the analysis that follows cropping decisions will be determined exogenously. In particular, the analysis considers two cropping pattern scenarios. The first scenario evaluates the economic consequences of nutrient constraints when cropping patterns are unaffected by increases in salinity levels. The second scenario allows cropping patterns to change in response to increasing salinity levels through the San Joaquin River Basin and Tulare Basin. In addition, the analysis considers alternative θ_r to represent the CAFO portion of available manure generation for each region and species.

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Manure transportation costs (TC) depend on the nutrient content of the manure (how it was stored), how it is applied, on the availability of land on which to apply the manure, and on what crops it is applied. Estimates for the transportation costs are based on a transportation cost model proposed by Fleming, Babcock and Wang (1998). The following equation is used to calculate TC.

(2a) $$TC_r = \sum_{i}(Ton_{i,r} \times X3_{i,r})(Spread_i + Dis_r \times Haul_i) \ ,$$

where Ton is the amount of manure produced per animal species, Spread and Haul represent spreading and hauling charges for each animal species and region, and Dis is the average distance greater than a mile within a region covered while spreading manure. We do not account for the fixed costs of specific technology types, such as the cost to purchase hauling equipment or to extend irrigation infrastructure. To determine the regional distance per affected CAFO (Dis), we regionalize the Fleming, Babcock, and Wang methodology for calculating search acreage. We assume that transportation of manure only occurs within a region because competition for land throughout each region, as can be inferred from the widespread excess nutrients throughout the regions

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6 Estimates of available manure nutrients by animal type are net the losses attributable to prevailing storage and handling technology Kellogg, R. L., et al. (2000) "Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States. ." Natural Resource Conservation Service, Economic Research Service, USDA, Washington, D.C.. Agronomic demand is calculated using crop uptake values for nitrogen and phosphorus, accounting for losses due to denitrification, subsurface flow, runoff, and leaching.

(see figure 3 and 4 below, in particular), will limit the ability of CAFOs to ship their manure outside the region.

3.5.3 Baseline Conditions

A baseline scenario for calibrating the above model comes from data collected from the California Department of Food and Agriculture, the United States Department of Agriculture, Iowa State University Extension, University of California Cooperative Extension, the University of California, Davis, and the Western Beef Development Centre. The model is delineated along Central Valley Production Model (CVPM) regions to complement the irrigated agriculture analysis to follow in Section 3.6. Each CVPM region in the model acts as a single productive unit who maximizes profits from dairy, hog, cattle, broiler, and layer operations. Each region takes the prices they receive for their output and the price they pay for their inputs as given by the market. Each region also produces the manure nutrients as a result of their production decisions, which must be managed accordingly. Each region also generates salt loads. These loads are based on salt load coefficients provided by Horner (2007). The results from the analysis are aggregated to the Basin level to complement the regional economic analysis also to follow. Although all three basins are analyzed, the main concern of salt loads is related to the San Joaquin River Basin and Tulare Basin where the baseline level of salt loadings from all AFOs is approximately 377,832 tons of salt each year.

Table 3.5.1shows the initial annual number of animals used to calibrate the model. These data are for the year 2005. Overall, and as noted above, the Central Valley AFOs are predominantly diary, broiler, and layer operations. The Sacramento River Basin is home to approximately 2% of the Central Valley dairy cows, 32% of the hogs, 31% of the cattle on feedlots, and less than 1% of the broilers, and layers. In comparison, 41% of the dairy cows, 26% of the hogs, 40% of the cattle, 23% of the broiler and, most notably, over 99% of the layers can be found in the San Joaquin River Basin. Tulare Basin, in contrast, is home to 56% of the dairy cows, 42% of the hogs, 29% of the cattle, 77% of the broilers, and less than 1% of the layers.

Table 3.5.1 Baseline Annual Animal Numbers by Basin

Basin	Dairy	Hog	Cattle	Broiler	Layer
Sacramento River	36,014	6,270	51,228	130,690	21,347
San Joaquin River	623,896	5,138	67,246	4,156,572	8,618,585
Tulare	843,750	8,290	49,005	14,005,610	13,257
Total	1,503,660	19,698	167,479	18,292,871	8,653,189

The baseline gross returns from these operations total close to $5.3 billion dollars. As such the model used in this analysis accounts for nearly 55% of the gross returns from all livestock and poultry production in California in 2005. Table 3.5.2 shows the baseline gross returns by basin. San Joaquin River Basin and Tulare Basin produce comparable annual gross returns of approximately $2.2 billion and $2.8 billion, or 42% and 54%, respectively, of gross returns to production.

Table 3.5.2. Baseline Gross Returns ($millions)

Basin	Gross Returns
Sacramento	$231.16
San Joaquin	$2,210.31
Tulare	$2,831.71
Total	$5,273.17

The baseline nutrient conditions can be seen in Figure 3.5.1 through Figure 3.5.4 when 60% of AFO manure and 30% of AFO manure are land applied under alternative WTAM scenarios in accordance with the assimilative capacity of the crops grown in each region. Figures 3.5.3 and 3.5.4 clearly show proper disposal of manure phosphorus will be limited in many regions of the San Joaquin River Basin and Tulare Basin even under a 30% WTAM scenario. These basins correspond to CVPM regions 8 through 13 and 14 through 21, respectively. These baseline excess nutrient levels suggest CAFOs will need to reduce their output in order to comply with the nutrient constraints. Although the demand for cropland as a disposal site for CAFO manure may create an incentive for farmers to switch cropping patterns to accommodate greater land application of manure nutrients, this possibility is not considered in this analysis given the compensation required to encourage farmers to switch out of producing high valued field crops and orchards.

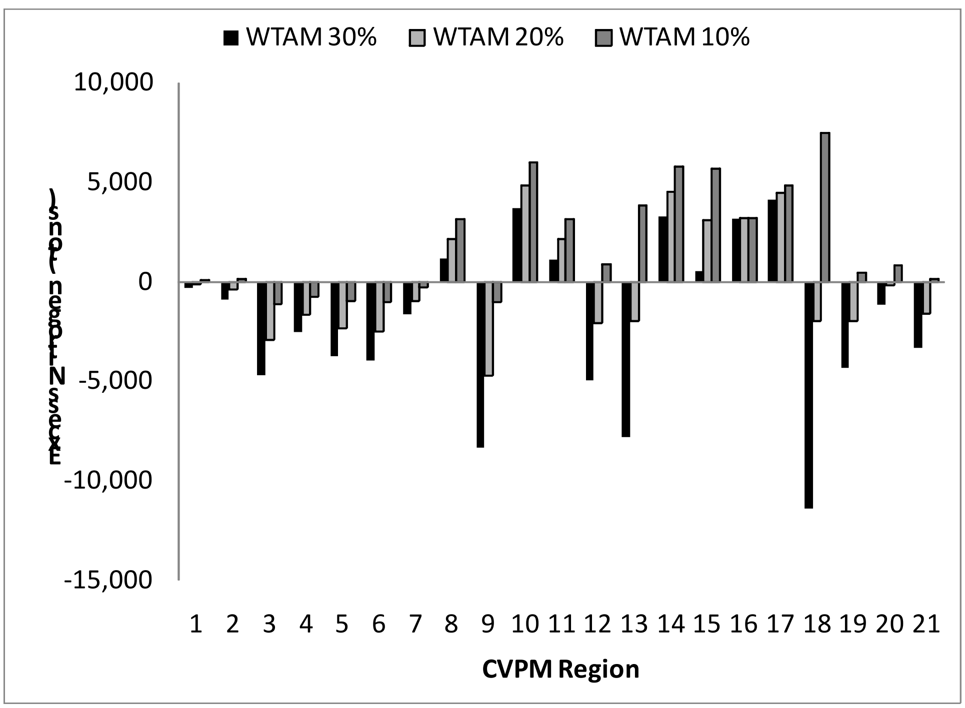

Figure 3.5.1 Excess Nitrogen When 60% of Manure is Land Applied

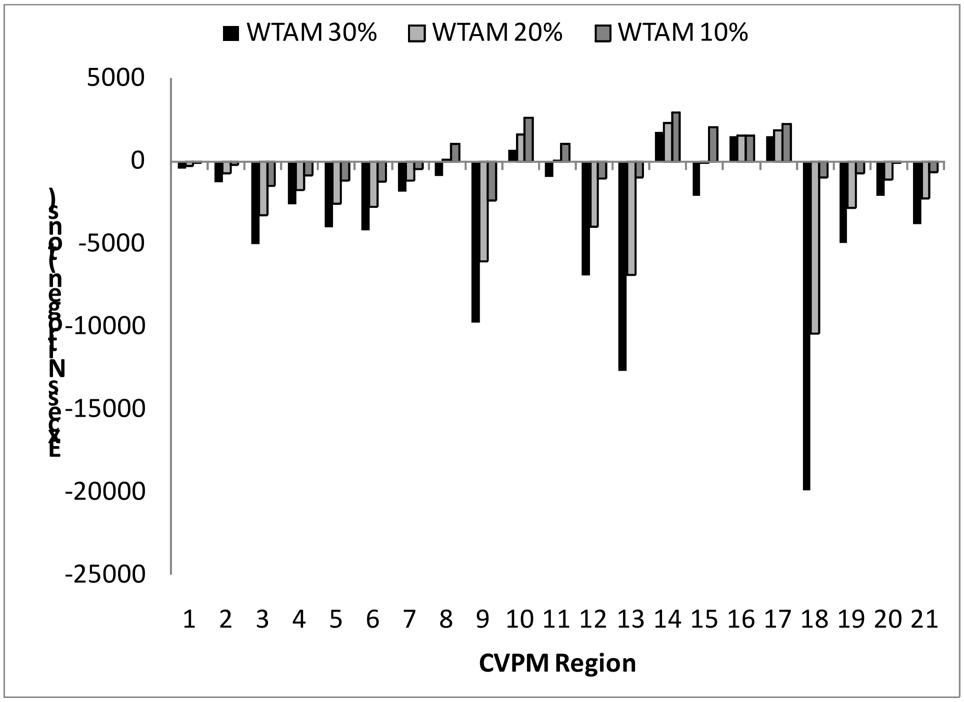

Figure 3.5.2 Excess Nitrogen When 30% of Manure is Land Applied

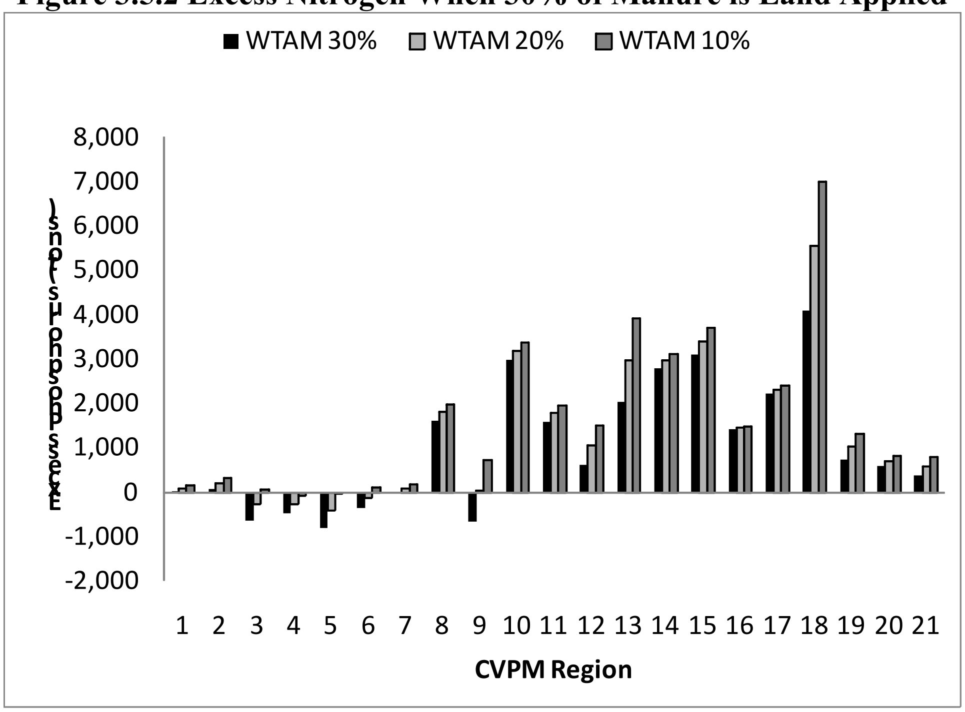

Figure 3.5.3 Excess Phosphorus when 60% of Manure is Land Applied

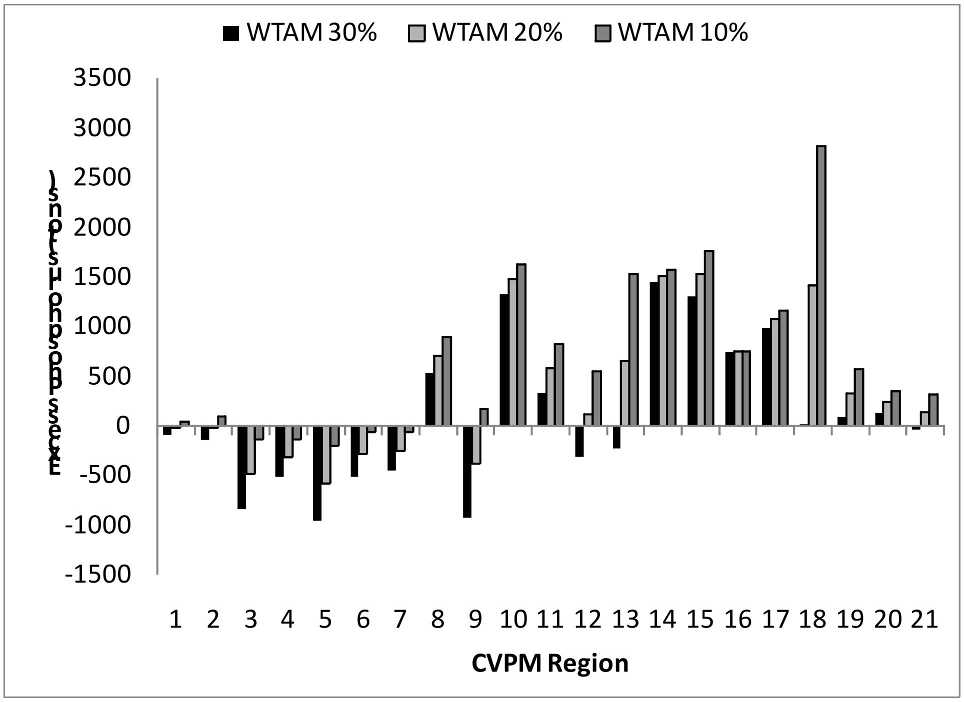

Figure 3.5.4 Excess Phosphorus When 30% of Manure is Land Applied

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3.5.4 Projected Growth

It is difficult to determine how animal agriculture in the Central Valley will grow over the next twenty to thirty years. Innovation and technology may provide solutions to the current nutrient situation in the Central Valley with AFOs at the center. In the absence of alternatives other than land application of manure nutrients, it is more likely to expect the departure of AFOs from the Central Valley then to see them grow in numbers. The earlier discussion on nutrient constraints suggests that growth in livestock and poultry operations throughout the Central valley may be limited by nutrient standards. Thus, for the purpose of this analysis it is assumed that these operations will not grow over the next 30 years.

3.5.5 Policy Analysis

The future of animal agriculture in the Central Valley will depend on the ability of producers to dispose of animal manure in accordance with Federal and state guidelines. A vital factor in determining how costly manure disposal will be is the acceptance of manure for land application by farmers throughout the region. If farmers are reluctant, and we suspect they are given various concerns related to manure use, then it may be very difficult for animal feeding operations to find land where they can properly spread their manure (Ribaudo, et al., 2003). Historically, we have seen manure used on 10-20% of grain crops (U.S. Department of Agriculture-Economic Research Services (USDA-ERS 2003). To evaluate the effect nutrient constraints has on CAFOs in the Central Valley, three WTAM scenarios (10%, 20%, and 30%) are simulated.

Also, it is clear from recent court decisions that not all animal feeding operations will be required to meet the nutrient standards established by EPA. Recent studies suggest up to 60 percent of the manure produced in the Pacific region comes from CAFOs. However, not all CAFOs will need to comply with nutrient constraints. As such, the scenarios account for two levels of compliance – 60 % of the manure in each region is land applied in accordance with nutrient standards and 30% of manure is land applied in accordance with nutrient standards. In some sense the 30% also accounts for the likelihood that not all CAFOs will comply even if they are required to do so by law. Table 3.5.2 shows all possible combinations of acceptance rates and compliance rates as well as the notation used for each scenario.

Table 3.5.3. CAFO Scenarios Used to Evaluate Economic and Salinity Impacts

	Manure Acceptance Rate		
Compliance Rate	10%	20%	30%
60% of Manure is Compliant	CAFO10	CAFO20	CAFO30
30% of Manure is Compliant	30CAFO10	30CAFO20	30CAFO30

Furthermore, to infer the economic consequences of increasing salinity levels, the model simulates CAFO production and land application of manure under two salinity scenarios. The first scenario, denoted as base crop acreage available for manure disposal, considers cropland available for manure disposal is unaffected by increasing salinity levels in terms of planted acreage. This scenario is then contrasted with a second scenario, denoted as salt-adjusted crop acreage for manure disposal, in which cropland acreage available for manure disposal is affected by increases in salinity levels, resulting in fewer acres being made available for land application of manure.

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3.5.6 Model Results

Gross returns before the introduction of nutrient constraints and increasing salinity levels was estimated to total nearly $5.8 billion annually. Table 3.5.4 presents the simulation results for gross returns in terms of percentage change from baseline gross returns. Table 3.5.5 highlights the change in gross returns attributed to increased salinity levels. Sacramento River Basin is relatively unaffected by the nutrient constraints. This can be explained by the limited animal feeding operations in this region of the Central Valley coupled with the sufficient cropland acreage available for accommodating the manure nutrients. The same cannot be said for San Joaquin River Basin or Tulare Basin. These regions see large losses in gross returns when the land application of manure nutrients is constrained. Gross returns across all basins decline at an increasing rate as the nutrient constraint becomes more stringent (i.e., a movement from 30% WTAM to 10% WTAM and from 30CAFO to CAFO). The largest loss of gross returns due to the nutrient constraints are seen in the Tulare Basin. In the most stringent of scenarios (CAFO10), when 60% of the manure is land applied in compliance with a nutrient constraint and only 10% of the cropland is available for manure land application, we see gross returns in Tulare Basin falling by over 75% when salinity levels are allowed to increase over time. In the least restrictive scenario (30CAFO30), returns fall by only 16% when salinity levels increase. The effect of increasing salinity levels on gross returns ranges from a low of over $64 million to a high of over $225 million. Most of these losses will occur in Tulare Basin, where cropland acreage will decline significantly thus further limiting the ability of CAFOs to properly dispose of their manure. In addition, it can be seen that the losses in gross value are greater in the more lenient scenarios when only 30% of AFO manure is land applied at agronomic rates. This result occurs because when the more stringent CAFO scenario is evaluated the base crop acreage for manure disposal results in larger losses in gross values relative to the 30CAFO scenarios (see table 3.5.4 for comparisons), and any additional reductions in cropland acreage that arise due to increasing salinity levels cannot reduce gross value by much more given it is extremely low already. However, the losses in gross value in the 30CAFO scenarios is less severe when salinity increases are not considered and thus when salinity levels increase and reduce cropland acreage, it in effect tightens the constraint for the 30CAFO scenarios more than it does for the CAFO scenarios.

Table 3.5.6 details the percentage change in the number of animals in each basin under each scenario. The AFOs in Sacramento River Basin are again relatively unaffected by the nutrient constraints. In the San Joaquin River Basin and Tulare Basin we see hog, broiler, and layer production bear the brunt of the nutrient constraints. These species generate more phosphorus be ton of manure than dairy or cattle, which explains why hog, broiler, and layer numbers decline at a greater rate than dairy and cattle operations. Table 3.5.7 illustrates the effect of increasing salinity levels on animal numbers in the San Joaquin River Basin and Tulare Basin. Salinity effects on animal number is greatest in the Tulare Basin where cropland acreage reductions are the greatest, resulting in less land available for manure application and thus greater reduction in animal numbers necessary to meet nutrient constraints. Furthermore, the increasing salinity levels appear to mostly affect dairy, cattle, and broiler operations. This occurs because hogs and layers are reduces to negligible levels even when salinity does not increase over time.

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Table 3.5.4. Percentage Change in Annual Gross Returns from Baseline by Region.

Base Crop Acreage Available for Manure Disposal

Scenario	SAC	SJR	TUL
CAFO30	-0.08%	-23.66%	-24.99%
CAFO20	-0.08%	-41.05%	-47.74%
CAFO10	-3.13%	-66.29%	-73.26%
30CAFO30	-0.04%	-7.72%	-7.90%
30CAFO20	-0.04%	-16.49%	-18.80%
30CAFO10	-0.04%	-41.04%	-47.74%

Salt-Adjusted Crop Acreage Available for Manure Disposal

Scenario	SAC	SJR	TUL
CAFO30	-0.08%	-24.30%	-28.53%
CAFO20	-0.08%	-41.49%	-51.52%
CAFO10	-3.13%	-66.51%	-75.35%
30CAFO30	-0.04%	-8.93%	-15.97%
30CAFO20	-0.04%	-17.35%	-23.75%
30CAFO10	-0.04%	-41.48%	-51.52%

Table 3.5.5. Gross Returns Attributable to Increasing Salinity Levels.

Scenario	SJR	TUL	Total
CAFO30	-$14,263,000.00	-$100,348,000.00	-$114,611,000.00
CAFO20	-$9,710,000.00	-$106,875,000.00	-$116,585,000.00
CAFO10	-$4,854,600.00	-$59,399,700.00	-$64,254,300.00
30CAFO30	-$26,862,000.00	-$228,265,000.00	-$255,127,000.00
30CAFO20	-$19,018,000.00	-$140,033,000.00	-$159,051,000.00
30CAFO10	-$9,709,000.00	-$107,017,000.00	-$116,726,000.00

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Table 3.5.6. Percentage Change in Animal Numbers Relative to Current Animal Numbers.

Base Crop Acreage Available for Manure Disposal

SACRAMENTO BASIN

	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	0.01%	-1.23%	-0.15%	0.01%	0.38%
CAFO20	0.01%	-1.23%	-0.15%	0.01%	0.38%
CAFO10	-2.67%	-18.02%	-3.39%	-0.10%	-3.47%
30CAFO30	0.00%	-0.56%	-0.07%	0.00%	0.27%
30CAFO20	0.00%	-0.56%	-0.07%	0.00%	0.27%
30CAFO10	0.00%	-0.56%	-0.07%	0.00%	0.27%

SAN JOAQUIN RIVER BASIN

	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-22.01%	-60.59%	-14.78%	-45.51%	-47.29%
CAFO20	-38.95%	-71.92%	-25.63%	-66.90%	-77.15%
CAFO10	-65.82%	-100.00%	-39.12%	-87.73%	-95.41%
30CAFO30	-6.70%	-15.45%	-3.01%	-20.21%	-22.01%
30CAFO20	-14.81%	-60.30%	-10.80%	-36.87%	-37.35%
30CAFO10	-38.93%	-71.71%	-25.62%	-66.97%	-77.26%

TULARE BASIN

Scenario	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-24.32%	-79.65%	-11.30%	-40.80%	0.62%
CAFO20	-46.99%	-100.00%	-27.70%	-68.26%	-72.17%
CAFO10	-72.88%	-100.00%	-43.14%	-95.10%	-72.17%
30CAFO30	-7.25%	-75.80%	-5.15%	-17.08%	0.36%
30CAFO20	-18.63%	-79.56%	-9.33%	-25.88%	0.36%
30CAFO10	-46.96%	-100.00%	-27.71%	-68.49%	-72.52%

Salt-Adjusted Crop Acreage Available for Manure Disposal

SACRAMENTO BASIN

	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	0.01%	-1.23%	-0.15%	0.01%	0.38%
CAFO20	0.01%	-1.23%	-0.15%	0.01%	0.38%
CAFO10	-2.67%	-18.02%	-3.39%	-0.10%	-3.47%
30CAFO30	0.00%	-0.56%	-0.07%	0.00%	0.27%
30CAFO20	0.00%	-0.56%	-0.07%	0.00%	0.27%
30CAFO10	0.00%	-0.56%	-0.07%	0.00%	0.27%

SAN JOAQUIN RIVER BASIN

	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-22.71%	-60.59%	-14.97%	-46.94%	-47.29%
CAFO20	-39.46%	-71.92%	-25.77%	-66.90%	-77.15%
CAFO10	-66.08%	-100.00%	-39.19%	-87.73%	-95.41%
30CAFO30	-7.96%	-15.45%	-3.35%	-22.77%	-23.06%
30CAFO20	-15.75%	-60.30%	-11.05%	-38.78%	-37.35%
30CAFO10	-39.44%	-71.71%	-25.76%	-66.97%	-77.26%

TULARE BASIN

	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-25.93%	-84.18%	-12.83%	-69.96%	-6.50%
CAFO20	-49.74%	-100.00%	-31.16%	-85.12%	-99.99%
CAFO10	-75.14%	-100.00%	-45.22%	-95.10%	-100.00%
30CAFO30	-14.96%	-75.80%	-7.98%	-32.67%	0.36%
30CAFO20	-21.97%	-79.56%	-10.32%	-53.42%	0.36%
30CAFO10	-49.74%	-100.00%	-31.17%	-85.14%	-100.00%

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Table 3.5.7. Difference and Percentage Change in Animal Numbers Due to Increasing Salinity Levels.

SAN JOAQUIN RIVER BASIN	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-4,399	0	-129	-59,455	0
CAFO20	-3,183	0	-93	0	0
CAFO10	-1,592	0	-47	0	0
30CAFO30	-7,858	0	-231	-106,200	-90,299
30CAFO20	-5,865	0	-172	-79,274	0
30CAFO10	-3,183	0	-93	0	0

SAN JOAQUIN RIVER BASIN	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-0.90%	-	-0.23%	-2.62%	-
CAFO20	-0.84%	-	-0.19%	-	-
CAFO10	-0.75%	-	-0.11%	-	-
30CAFO30	-1.35%	-	-0.35%	-3.20%	-1.34%
30CAFO20	-1.10%	-	-0.29%	-3.02%	-
30CAFO10	-0.84%	-	-0.19%	-	-

TULARE BASIN	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-13578	-376	-750	-4,083,857	-944
CAFO20	-23,253	0	-1,695	-2,360,145	-3688
CAFO10	-19,120	0	-1,021	0	-3690
30CAFO30	-65,065	0	-1,389	-2,183,887	0
30CAFO20	-28,213	0	-488	-3,856,777	0
30CAFO10	-23,433	0	-1,698	-2,331,780	-3644

TULARE BASIN	Dairy	Hog	Cattle	Broiler	Layer
CAFO30	-2.13%	-22.28%	-1.73%	-49.25%	-7.08%
CAFO20	-5.20%	-	-4.78%	-53.10%	-99.95%
CAFO10	-8.36%	-	-3.66%	-	-
30CAFO30	-8.31%	-	-2.99%	-18.80%	-
30CAFO20	-4.11%	-	-1.10%	-37.15%	-
30CAFO10	-5.24%	-	-4.79%	-52.83%	-

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Changes in animal numbers correspond to changes in salt loads from AFOs. Table 3.5.8 and 3.5.9 show the effect of the nutrient constraints on salt loads across San Joaquin River Basin and Tulare Basin and the effect of increasing salinity levels on salt loads from AFOs in these basins. As might be expected, when animal numbers fall so does the salt loads from AFOs. However, the effect of increasing salinity levels throughout these basins does not significantly reduce salt beyond the reductions attributable to the nutrient constraints. The salt load reductions under the various nutrient constraints when salinity levels increase range between 19% (30CAFO30) and 73% (CAFO10). These reductions correspond to between 71,619 and 275,999 tons. In comparison, the reduction in salt loads attributable to increasing salinity levels and thus reduction in crop acreage for disposing of the manure nutrients range between 4,592 tons to over 17,375 tons.

Table 3.5.8. Combined Salt Load for San Joaquin and Tulare Basins.

Base Crop Acreage Available for Manure Disposal

Scenario	Salt Load (tons)	% change from Baseline
CAFO30	266,331	-29.51%
CAFO20	195,614	-48.23%
CAFO10	106,426	-71.83%
30CAFO30	323,589	-14.36%
30CAFO20	288,894	-23.54%
30CAFO10	195,658	-48.22%

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Salt-Adjusted Crop Acreage Available for Manure Disposal

Scenario	Salt Load (tons)	% change from Baseline
CAFO30	259,642	-31.28%
CAFO20	188,148	-50.20%
CAFO10	101,833	-73.05%
30CAFO30	306,213	-18.96%
30CAFO20	278,954	-26.17%
30CAFO10	188,171	-50.20%

Note: San Joaquin and Tulare Basin Baseline Salt Loads 377,832.24 tons

Table 3.5.9. Change in Salt Load due to Increasing Salinity Levels.

Scenario	Change in Salt Load (tons)	Percentage Change
CAFO30	-6,688.63	-2.51%
CAFO20	-7,466.66	-3.82%
CAFO10	-4,592.75	-4.32%
30CAFO30	-17,375.38	-5.37%
30CAFO20	-9,939.73	-3.44%
30CAFO10	-7,487.28	-3.83%

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3.6 Estimating the Impacts of Salinity on Irrigated Agricultural Production in the San Joaquin Valley

3.6.1 Introduction

Agricultural crop production is the dominant industry in the San Joaquin Valley and is also the major generator of salinity and, in turn, suffers the greatest economic impact from salinity changes. In addition, ### of the employment in the valley is related to agricultural crop production, as is, much of the secondary food-processing industry. It is thus critical that any socio-economic analysis of the impact of salinity on this region must accurately model irrigated crop production as the fundamental economic driving variable in the region.
In this section we develop two modeling approaches to estimate the effect of increased salinity on crop production in the San Joaquin Valley. Both models are combined to project the changing cropping patterns due to salinity accumulation in 2030. The direct economic impacts of crop changes are also calculated. In the section 3.4 we show the effect of increased salinity costs on the crop processing industry, and finally, the effect of increases in these costs on the likelihood of crop processing industries leaving the area.

3.6.2 Methods

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To contrast deductive and inductive approaches in agricultural production patterns under increasing salinity conditions, this paper respectively uses positive mathematical programming and a multinomial logit model.

Positive mathematical programming (PMP after Howitt, 1995) is a deductive approach for evaluating the effects of policy changes on cropping patterns at the extensive and intensive margins. The model presented in this paper is a combination of two preceding models using PMP: the Statewide Agricultural Production Model, or SWAP (Howitt, et al., 2001) and the Delta Agricultural Model, or DAP (in Lund, et al., 2007).

Both SWAP and DAP are three-step, self-calibrating programming models that assume farmers behave in a profit maximizing fashion. For both models, in the first step, a linear program for profit maximization is solved. In addition to the traditional resource and non-negativity constraints, a set of calibration constraints is added to restrict land use to *observed* values. The second step is parameterization of a quadratic cost function a non-linear production function itself, from the first order conditions. A third and last step incorporates the recently parameterized functions into a non-linear profit maximization program, with constraints on resource use. The main difference in the models is that DAP incorporates salinity considerations as a reduction in yields due to soil root zone salinization following

3.6.2.1 Production Function

A Constant Elasticity of Substitution (CES) production function is proposed, and parameterized as in Howitt (2006). Elasticity of substitution is assumed to vary by crop but not by region. The specification of the generalized CES production function (Beattie and Taylor, 1985) is:

$$Y_{gi} = \tau_{gi}\left[\sum_{j} \beta_{gij} X_{gij}^{-\rho_i}\right]^{-\upsilon/\rho_i} \qquad (1)$$

Sub-index g corresponds to the CVPM region, i refers to crops, and j to production factors or inputs. The model in this study has three inputs: land, labor and water. Also in equation 1 above, Y_{gi} represents the output for crop i in region or group g. The scale parameter of the CES production function is referred as τ_{gi}, whereas the share parameters for the resources for each crop, are represented by β_{gij}. The X_{gij} denotes usage of factor j in production of crop i of region g.

The functional form is homogeneous of degree υ, and the elasticity of substitution for crop i, σ_i is given by $\sigma_i=1/(1+\rho_i)$. The function coefficient (returns to scale) is also given by parameter υ.

The first step in PMP is devoted to obtaining marginal values for the calibration constraints to parameterize a quadratic cost function in the second step. The linear program with calibration constraints is as follows:

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$$Max_{x\geq 0}\prod = \sum_{g}\sum_{i}(v_{gi}yld_{gi} - \sum_{j}\omega_{gij}a_{gij})x_{gi,land} \qquad (2)$$

$$Ax \leq b \qquad (3)$$

$$Ix = \tilde{x} + \varepsilon \qquad (4)$$

$$Ix = \tilde{x} - \varepsilon \qquad (5)$$

Equation 2 is the objective function of the linear program. Decision variables are $x_{gi,land}$ that are the total acres planted for region or group g and crop i. The marginal revenue of crop i in region g, is given by v_{gi}. Average yields are given by yld_{gj} take into account reductions in salinity due to the base soil salinity levels following van Genuchten and Hoffman (1984).

Average variable costs ω_{gji} are used also in the linear profit objective function 2. The Leontieff coefficients a_{gji} are given by the ratio of total factor usage to land. In other words, all production inputs are normalized with respect to land, therefore $a_{gi,land}$ is expected to be one for all crops and regions.

Equations 3-5 are in matrix form. In the resource constraint set (equation 3), matrix **A** is three-dimensional (G I K) with regional Leontief coefficients a_{gkj} as elements. K is a subset of the resources set, that includes only those resources in limited amounts. In the same equation, **x** is a (K by 1) column vector of the decision variables $x_{gi,land}$. Vector **b** is the regional limit on the resource with dimensions J by 1. The last two sets (4 and 5) are for the upper and lower bounds of the calibration constraints, where **I** is a J by J identity matrix, the *x-tilde* is the observed value of resources usage, whereas ε is small perturbation that decouples the resource and calibration constraints.

The second step in PMP estimation is to calculate parameters needed by the exponential cost function and the CES production function. The cost function is given by equation 6 below:

$$TC_{gij}(x_{gij}) = \delta_{gi} e^{\gamma_{gi} x_{gi,land}} \qquad (6)$$

where δ_{gi} and $\gamma_{gi,land}$ are respectively intercept and parameter of an exponential cost curve. These parameters are obtained from an ordinary least squares regression with restrictions on the PMP formulation and elasticities of supply for each crop.

The last step in PMP is to solve a non-linear constrained profit maximization program. The objective function becomes:

$$Max_{x\geq 0} \prod = \sum_{g}\sum_{i} yred_{gi} v_{gi} Y_{gi} - \sum_{g}\sum_{i} \delta_{gi} e^{\gamma_{gi} x_{gi,land}} - \sum_{g}\sum_{i}\sum_{j, j\neq land}(\omega_{igj} x_{gij}) \qquad (7)$$

subject to:

$$Ax \leq b \qquad (8)$$

$$xm_{gm} \leq \sum_{i} met_{gim} x_{gi,water} \quad \forall g,m \qquad (9)$$

$$\sum_{m} xm_{g,m} \leq availwater \cdot b_{water,g} \quad \forall\, g \qquad (10)$$

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In equation 7, Y_{gi} is defined by the production function in above, the derivation of parameters τ_{gi} and β_{gij} of the production function is detailed in Medellin-Azuara (2006). The second term in the equation has now the PMP calibrated cost function. Constraint 8 is as in 3 above, except that all resources are included not just those limited.

Yield reductions in equation 7 of van Genuchten and Hoffman (1984) are detailed in equation 11 below, in which $Ymax_{g,i}$ is the maximum average yield of crop *i* in region *g*;c_{gi} is the salinity in the root zone, c_{50gi} is the salinity at which the yield is reduced by 50%, and *p,* is an empirical constant.

$$yred_{gi} = \frac{Y_{\max gi}}{1+\left({c_{gi}}/{c_{50_{gi}}} \right)^{P}} \qquad (11)$$

A new constraint set on monthly water use has been included. Variable xm_{gm} in equation 9 is monthly water use in region *g* in month *m*. Three underlying assumptions are worth discussing. First, water is interchangeable among crops within a region. Second, a farm group (or region) maximizes profits on a yearly basis, equalizing marginal revenue to marginal costs every month. Third, a region or farm group picks the crop mix that maximizes profits within the region. In other words, the shadow value of water will be the same for all months and for all crops *i* in a region or farm group *g*. This assumes sufficient levels of water storage and internal water distribution capacity and flexibility.

The last constraint set (10) is for regional water in which, $b_{water,g}$ corresponds to that in the right hand side of equation 8 for water. The parameter *availwater* can be used later to obtain shadow values of water by constraining water regionally, such that 0<availwater $\leq$ 1. The constraint set assumes that yearly water is available in a limited amount for every region or group. Less realistically, it also implies that water is not re-traded across groups or regions under the basic calibration assumptions.

To estimate the effects of salinity changes in the root zone, the base salinity c_{gi} in equation 11 is increased. The policy experiment is performed by recalculating input usage and production from equations 7 to 10 at the new salinity levels. Cultivated land is then compared to that predicted by the multinomial logit model below.

3.6.3 An Econometric Test of Deductive Cropping Models

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To compare with the deductive approach of the SWAP model an inductive econometric approach is conducted using a multinomial logit model. These models have seen extensive use in economic literature, widely used in transportation choice models and spreading to agriculture and resource research. Multinomial logit models have been used to model watering technology adoption and choice (Lichtenberg 1989, Caswell and Zilberman 1985). This model has also been applied to crop rotation and tillage choice (Wu and Babcock 1998, Wu et.al. 2004) in addition to land use choices (Hardie and Parks 1997, Wu and Segerson 1995). In contrast to previous work, this paper uses the multinomial logit model as an inductive tool to difference with the deductive results of SWAP. The probability of observing a crop, given soil quality, salinity, and plot acreage is estimated, from these estimates we calculate the marginal effects of salinity and determine the resulting acreage changes.

As soil salinity levels change we can expect to observe changing crop rotations. Extensive literature exists on the effects of salinity on agriculture and these salinity problems are a global issue (Schwabe et al 2006). Increases in soil salinity reduce crop yields and cause farmers to shift away from high value salt intolerant crops to lower value salt tolerant rotations. This effect on changing crop rotations will also be seen through a shift to larger plot sizes to accommodate the more salt tolerant plants. Including soil quality and plot acreage in the multinomial logit model will isolate the effects of salinity on crop rotations.

Consistent with SWAP models the data are analyzed on a CVPM basis. Each parcel in the data set contains information on the crop observed, parcel area, soil salinity, and soil quality. Crop is coded as an integer variable ranging from 1 to 11 (or 12), representing each crop type. CVPM's 14, 15, and 19 contain 12 alternative crops and CVPM's 10 and 21 contain 11 alternatives as tomatoes are not grown in these regions. Parcel acreage is a continuous measure of parcel area in acres and is interpreted as a proxy for farm plot size. Salinity level and soil quality are both represented as integer variables ranging from 0 to 4 and 0 to 7, respectively, with higher values indicating increasing salinity and decreasing soil quality. The data are summarized in table 3.6.1 and crop occurrence by CVPM is summarized in table 3.6.2.

Table 3.6.1. Summary of Data

CVPM 10					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Crop	10455	5.12	3.18	1	11
Acres	10455	65.82	92.21	0.05	1863.02
Zone	10455	0.74	0.89	0	4
Soil	10455	3.39	1.78	0	7
CVPM 14					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Crop	7394	6.72	3.77	1	12
Acres	7394	213.55	771.37	0.05	13643.9
Zone	7394	1.4	1.38	0	5
Soil	7394	6.38	1.59	0	7
CVPM 15					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Crop	11461	5.25	3.07	1	12
Acres	11461	99.03	343.24	0.08	13643.9
Zone	11461	0.5	1.02	0	5
Soil	11461	2.76	1.25	0	7
CVPM 19					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Crop	4705	4.42	2.89	1	12
acres	4705	135.43	325.34	0.1	6888.21
Zone	4705	1.11	1.31	0	5
Soil	4705	6.25	1.78	0	7
CVPM 21					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Crop	4224	5.91	3.37	1	11
acres	4224	124.79	263.15	0.69	4155.28
Zone	4224	0.27	0.63	0	3
Soil	4224	6.27	1.36	2.11	7

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Table 3.6.2. Summary of Crop Occurrence.

Percentage of Crop Acreage Observed by CVPM					
Crop	**CVPM 10**	**CVPM 14**	**CVPM 15**	**CVPM 19**	**CVPM 21**
Alfalfa	18.94%	5.21%	14.54%	19.51%	11.77%
Citrus	0.56%	0.32%	0.46%	0.79%	4.19%
Cotton	16.47%	29.56%	19.57%	31.67%	14.06%
Field	16.93%	4.15%	12.83%	4.78%	10.84%
Grain	2.62%	8.63%	7.04%	14.22%	13.26%
Orchard	15.77%	9.44%	21.05%	13.71%	8.71%
Pasture	5.60%	0.70%	3.39%	0.51%	1.96%
Sugar Beet	1.70%	1.70%	0.84%	1.55%	0.17%
Table	0.37%	2.45%	8.06%	2.83%	7.62%
Truck	14.55%	11.27%	0.72%	4.21%	18.63%
Fallow	5.52%	10.75%	10.15%	5.10%	8.78%
Tomato	0.00%	15.81%	1.34%	1.13%	0.00%

Given that plot size, salinity levels, and soil quality are invariant across crop alternatives the appropriate model is multinomial logit (MNL) (Green 2003 p.720). Proceeding as in Green (Green 2003, p.721), let $p_{ij} = \Pr[y_i = j]$, the probability of observing crop j on field plot i. Since we do not seek to capture the effect of microclimate in the multinomial logit model, we specify six independent models, one for each CVPM, where microclimate has been controlled for. The multinomial logit models can be written as:

$$p_{ij} = \frac{e^{\mathbf{x}_i'\beta_j}}{\sum_{l=1}^{12} e^{\mathbf{x}_i'\beta_l}}$$, where $j = 1, 2, ..., 12$ for CVPM's 14, 15, and 19

$$p_{ij} = \frac{e^{\mathbf{x}_i'\beta_j}}{\sum_{l=1}^{11} e^{\mathbf{x}_i'\beta_l}}$$, where $j = 1, 2, ..., 11$ for CVPM's 10 and 21

Define $\mathbf{x}$ as a vector of the alternative invariant regressors: parcel acreage, soil salinity level, and soil quality measure. Since $\sum_{j=1}^{12} p_{ij} = 1$, i.e. the probabilities sum to one, it is necessary to impose a restriction to ensure identification (Green 2003 p.721). For our model we restrict $\beta_1 = 0$. Consequently, all estimates are produced with alfalfa (crop 1) as the base outcome. All coefficient estimates are interpreted as: compared to alfalfa the likelihood of observing a crop j changes by β_j.

Each model is run specific to a CVPM, where each CVPM is assumed independent of neighboring areas. Estimated coefficients are reported in table 3.6.3 for reference, marginal effects are estimated later and serve to better interpret the results. Likelihood Ratio tests are reported, test statistics exceed the respective chi-square critical value indicating good predictive power of the

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models. To test for heteroskedasticity models were run with robust standard errors resulting in no change in standard error or coefficient estimates, indicating robust results. The majority of coefficient estimates are significant at the 1% - 5% level, with even more significant at the 10% level. Statistically insignificant coefficient estimates are largely due to a poor number of observations of a specific crop. For example, in CVPM 18 Cotton is only observed in 8.3% of parcels in the dataset and coefficient estimates on soil salinity and acreage are insignificant. There is no theoretical basis to justify dropping these crops from the regression models, and the estimation results are not significantly affected. All crops are included in the final models.

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Table 3.6.3. Summary of Estimation Results

	CVPM 10		CVPM 14		CVPM 15		CVPM 19		CVPM 21	
Crop	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Citrus										
acres	-0.0380	0.0070	-0.0286	0.0064	-0.0450	0.0086	-0.0046	0.0033	0.0002	0.0005
zone	-0.7876	0.2216	-1.4530	0.2710	0.2255	0.1355	0.3899	0.1290	-32.7071	.
Soil	0.1438	0.0964	5.7181	0.0476	0.2120	0.1278	0.2059	0.1780	-0.5418	0.0602
constant	-2.1849	0.3504	-38.5613	.	-2.6268	0.3722	-4.7603	1.3044	2.4833	0.3704
Cotton										
acres	0.0047	0.0005	0.0004	0.0002	0.0013	0.0002	0.0037	0.0005	0.0007	0.0002
zone	0.0923	0.0390	-0.6212	0.0467	0.1431	0.0296	0.1851	0.0343	0.0108	0.0816
Soil	0.0739	0.0207	-0.0135	0.0329	-0.0375	0.0295	-0.0030	0.0300	0.1097	0.0658
constant	-0.8320	0.0726	3.1035	0.2516	0.1577	0.0853	-0.0899	0.2193	-0.6716	0.4364
Field										
acres	-0.0047	0.0007	-0.0029	0.0006	-0.0041	0.0004	0.0014	0.0008	-0.0004	0.0003
zone	-0.1562	0.0413	-0.8778	0.0632	-0.1862	0.0416	-0.1720	0.0650	-0.0061	0.0889
Soil	0.0655	0.0215	0.0821	0.0522	-0.3272	0.0390	-0.1745	0.0421	-0.0793	0.0602
constant	0.0560	0.0738	1.3622	0.3793	1.0565	0.0994	-0.2608	0.3046	0.4897	0.3949
Grain										
acres	0.0029	0.0008	0.0003	0.0002	0.0012	0.0002	0.0035	0.0005	-0.0006	0.0003
zone	-0.1299	0.0681	-0.5946	0.0526	0.2081	0.0366	0.2065	0.0398	-0.0827	0.0868
Soil	0.0895	0.0347	-0.1114	0.0361	0.0564	0.0370	-0.1990	0.0308	-0.1372	0.0557
constant	-2.0490	0.1227	2.4617	0.2727	-1.1749	0.1114	0.2942	0.2244	1.1132	0.3646
Orchard										
acres	-0.0056	0.0008	-0.0013	0.0004	-0.0065	0.0004	0.0041	0.0005	-0.0009	0.0005
zone	-1.2975	0.0589	-1.4308	0.0618	-1.4398	0.0836	-0.3996	0.0496	-1.1930	0.1805
Soil	0.1029	0.0232	-0.0202	0.0401	0.1841	0.0277	-0.1675	0.0318	-0.2587	0.0569
constant	0.4344	0.0806	3.0886	0.2958	0.5831	0.0812	0.5714	0.2264	1.6777	0.3678
Pasture										
acres	-0.0096	0.0012	-0.0182	0.0030	-0.0303	0.0025	0.0041	0.0006	-0.0470	0.0062
zone	-0.3134	0.0620	-0.1429	0.1142	0.2114	0.0580	-0.5287	0.2441	0.0445	0.1982
Soil	0.1941	0.0305	-0.1604	0.0732	-0.0788	0.0655	0.0546	0.1616	-0.0695	0.1047
constant	-1.1389	0.1103	1.0669	0.5757	-0.1990	0.1666	-4.0514	1.1178	0.5286	0.6817
Sugar Beet										
acres	0.0020	0.0010	-0.0015	0.0008	-0.0002	0.0008	-0.0082	0.0028	0.0000	0.0017
zone	0.6268	0.0833	-0.2089	0.0814	0.1620	0.0852	-0.2203	0.1196	-0.4837	0.6246
Soil	0.1811	0.0479	-0.0286	0.0582	0.3504	0.0681	0.1426	0.1319	11.3866	0.0656
constant	-4.0442	0.1913	-0.1688	0.4444	-4.0040	0.2521	-2.7495	0.9403	-83.5623	.
Table										
acres	0.0054	0.0011	-0.0032	0.0008	0.0009	0.0003	0.0031	0.0007	0.0010	0.0003
zone	-0.8442	0.2312	-1.6699	0.1124	-2.5551	0.3053	-2.5914	0.4728	-2.9335	0.5455
Soil	0.2946	0.0889	0.1310	0.0712	0.3350	0.0310	-0.2127	0.0457	-0.2479	0.0590
constant	-4.8206	0.3668	1.0562	0.5021	-1.3488	0.1017	-0.2006	0.3149	1.3178	0.3799
Truck										
acres	0.0037	0.0005	-0.0010	0.0003	-0.0049	0.0016	0.0001	0.0011	-0.0024	0.0005
zone	-0.4685	0.0435	-0.8936	0.0523	0.0392	0.1051	-0.2153	0.0754	-1.1553	0.1331
Soil	0.2307	0.0212	0.2060	0.0450	0.3201	0.0779	0.3889	0.1312	-0.2847	0.0506
constant	-0.9688	0.0769	1.3309	0.3298	-3.5832	0.2672	-3.9946	0.9265	2.7121	0.3299
Fallow										
acres	-0.0075	0.0011	-0.0012	0.0004	-0.0005	0.0003	0.0012	0.0008	-0.0002	0.0003
zone	-0.3333	0.0617	-0.7398	0.0516	0.2482	0.0331	0.1060	0.0564	-0.2083	0.1015
Soil	0.2236	0.0303	-0.0408	0.0367	0.0835	0.0333	-0.1806	0.0412	-0.1729	0.0594
constant	-1.3346	0.1103	2.7233	0.2773	-0.7284	0.0996	-0.4320	0.3034	0.9236	0.3865
Tomato										
acres	.	.	0.0000	0.0002	0.0012	0.0002	-0.0004	0.0021	.	.
zone	.	.	-0.8772	0.0500	0.3174	0.0627	-0.0495	0.1235	.	.
soil	.	.	0.2045	0.0413	0.3688	0.0537	0.1019	0.1291	.	.
constant	.	.	1.5060	0.3050	-3.9380	0.2040	-3.4469	0.9322	.	.

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Coefficient estimates of multinomial logit models are difficult to interpret for policy analysis as they are not elasticities or marginal probability changes. As such, to yield interpretable results marginal effects are computed as nonlinear combinations of the predictor variables as shown in Green (Green 2003 p.722). The marginal effects take the form:

$$p_{ij}\left(\beta_j - \sum_{l=1}^{12} p_{il}\beta_l\right)$$

We estimate the marginal effects in the form $\frac{\partial \Pr[crop = i]}{\partial x_i}$ where x_i is the soil salinity variable. In order to capture the true marginal effects of salinity zone on crop rotation we evaluate marginal effects by discreetly increasing salinity zone from 0-1, 1-2, 2-3, and 3-4, yielding 4 sets of marginal effects. All other variables are held constant at the respective mean during the computation. Additionally, we evaluate the marginal effect of salinity at the mean (the standard approach), yielding a fifth marginal effects estimate and these results are presented in table 3.6.4. Marginal effects are interpreted as the percentage change in observing a crop resulting from a one unit (discreet) increase in salinity zone, all else constant at the mean.

Table 3.6.4. Summary of Marginal Effects.

	CVPM 10			CVPM 14			CVPM 15			CVPM 19			CVPM 21		
Crop	**Base**	**Marginal**	**SE**	**Base**	**Marginal**	**SE**	**Base**	**Marginal**	**SE**	**Base**	**Marginal**	**SE**	**Base**	**Marginal**	**SE**
Alfalfa	20.75%	5.79%	0.508	3.58%	2.71%	0.139	19.03%	4.52%	0.424	19.37%	-0.40%	0.488	13.40%	6.87%	2399
Citrus	0.17%	-0.09%	0.045	0.00%	0.00%	0.000	0.03%	0.01%	0.011	0.50%	0.18%	0.069	0.00%	-0.03%	18230
Cotton	16.97%	6.30%	0.438	33.42%	4.57%	0.430	24.45%	9.30%	0.446	35.20%	5.80%	0.574	14.88%	7.80%	2663
Field	17.93%	2.21%	0.499	3.74%	-0.45%	0.166	13.42%	0.69%	0.426	5.01%	-0.96%	0.281	21.61%	6.40%	2258
Grain	3.99%	0.60%	2.430	9.51%	1.55%	0.259	8.60%	3.83%	0.248	15.16%	2.82%	0.392	15.66%	6.74%	2814
Orchard	12.07%	-12.29%	0.456	6.96%	-4.69%	0.241	14.47%	-17.40%	0.691	13.53%	-5.68%	0.462	9.14%	-6.22%	1707
Pasture	5.42%	-0.19%	0.291	0.06%	0.04%	0.009	0.69%	0.31%	0.066	0.46%	-0.25%	0.090	0.04%	0.02%	7.505
Sugar Beet	1.22%	1.10%	0.105	1.36%	0.75%	0.088	0.97%	0.39%	0.082	0.78%	-0.19%	0.097	0.00%	0.00%	0.012
Table	0.35%	-0.20%	0.073	1.16%	-1.06%	0.121	3.74%	-8.67%	0.319	0.36%	-0.94%	0.318	5.38%	-13.02%	1302700
Truck	15.58%	-2.95%	0.468	11.49%	-1.56%	0.293	0.80%	0.22%	0.083	3.21%	-0.76%	0.226	18.34%	-11.78%	3420
Fallow	5.56%	-0.30%	0.297	11.39%	0.21%	0.285	12.44%	6.04%	0.301	5.37%	0.46%	0.255	10.54%	3.21%	1901
Tomato	.	.	.	17.32%	-2.07%	0.354	1.36%	0.75%	0.087	1.04%	-0.07%	0.125	.	.	.

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3.6.4 Model Results

The results show strong support for the theory of the model and coincide with SWAP results. All else constant, more salt tolerant crops are more likely to be observed as soil salinity increases. Table 3.6.5 shows the average marginal effect of salinity by crop against the approximate salt tolerance of the respective crop, sorted by CVPM.

Table 3.6.5. Marginal Effects by Salt Tolerance.

Marginal Effects						
Crop	**dS/m***	**CVPM 10**	**CVPM 14**	**CVPM 15**	**CVPM 19**	**CVPM 21**
Citrus	1	-0.09%	0.00%	0.01%	0.18%	-0.03%
Table	1	-0.20%	-1.06%	-8.67%	-0.94%	-13.02%
Orchard	1.4	-12.29%	-4.69%	-17.40%	-5.68%	-6.22%
Truck	1.5	-2.95%	-1.56%	0.22%	-0.76%	-11.78%
Tomato	1.7	.	-2.07%	0.75%	-0.07%	.
Grain	4.5	0.60%	1.55%	3.83%	2.82%	6.74%
Sugar Beet	4.7	1.10%	0.75%	0.39%	-0.19%	0.00%
Field	5	2.21%	-0.45%	0.69%	-0.96%	6.40%
Cotton	5.1	6.30%	4.57%	9.30%	5.80%	7.80%
Alfalfa	8	5.79%	2.71%	4.52%	-0.40%	6.87%
Pasture	n/a	-0.19%	0.04%	0.31%	-0.25%	0.02%
Fallow	n/a	-0.30%	0.21%	6.04%	0.46%	3.21%

* Obtained from http://www.agric.nsw.gov.au/reader/wm-plants-waterquality

In response to the inherent spatial dimension of the data we investigate possible spatial modeling techniques. The reasons for pursuing this method of estimation are three-fold: theoretical, analytical, and model driven. From a theoretical perspective, if soil salinity is changing over time and crop rotations are adjusting accordingly, as the GIS maps indicate, there may be a diffusion type effect to this process. This diffusion process may be captured in a spatial model. Analytically, it is possible that crop rotation is determined by farm management with little attention paid to salinity and soil quality. This would indicate multinomial logit parameter estimates and marginal effects overstate the effect of salinity. Finally, spatial effects are explored to ensure the robustness of multinomial logit model estimates.

In the absence of observations on farm management companies or any temporal component to our data set, we explore spatial methods to capture the effects above. Anselin 1988 outlines the basics of spatial modeling and shows that if there is an omitted spatial variable, parameter estimates are inconsistent (Anselin 1988). Extensive literature exists on programming for traditional spatial modeling, and limited dependent variable with spatial effects analysis (Anselin and Hudak 1992, Anselin 2002, Flemming 2006, Anselin et al 2004). For ease of computation and clear interpretation of results, the data are converted from discrete to continuous observations. Using GIS, each CVPM was overlaid with a 1km by 1km grid. Each 1km by 1km cell was assigned a weighted value for "crop" based on low, medium, and high value rotations. Similarly, each cell was assigned a weighted value for soil quality and salinity. Acreage was dropped from the model as all observations were one square km.

Using the constructed continuous variables we were able to investigate a spatial mixed autoregressive model, a Bayesian spatial autoregressive model, and a

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locally linear spatial model (LeSage 1998, LeSage 1999). Results showed that there is a spatial component to the data, with statistically significant coefficient estimates for spatial autocorrelation. However, including spatial effects in the models added no predictive power and reduced salinity and soil estimates to near zero. The conclusion is that the clustering of observations is driven by soil quality and salinity content, and adding spatial effects contributes nothing to the model. This reinforces confidence in multinomial logit parameter estimates without spatial effects. It should be noted that a more comprehensive approach to spatial modeling of crop rotation could be conducted to explore the effects of management or diffusion with a data set that included observations over time.

3.6.5 Comparing Models of Salinity Impacts in the San Joaquin Valley.

3.6.5.1 Land Use

California Central Valley is used as the case study for this paper. The agricultural sub regions are defined as 21 CVPMs (Figure 3.6.1) totaling 12.75 million acres. Cultivated land came from DWR georeferenced land use surveys available at http://www.landwateruse.water.ca.gov/basicdata/landuse/landuselevels.cfm.

Each georeferenced element in the land use surveys contains among other information, area, as well as current and previous information on land use. Agricultural land use is tiered into crops and also indicates whether it was fallow land during the surveys. Urban, native and other land use classes are also indicated for each element in the survey.

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Crop groups for the study were alfalfa, citrus, cotton, field crops, grains, orchards, pasture, sugar bet, all grapes, truck and other crops. An example of crop distribution in CVPM 21 is shown in Table 3.6.6. It can be noticed in the aforesaid table that low value crops are concentrated in the high salinity zones. Also it can be noticed in Figure 3.6.2 that the electrical conductivity depicts some correlation with soil class.

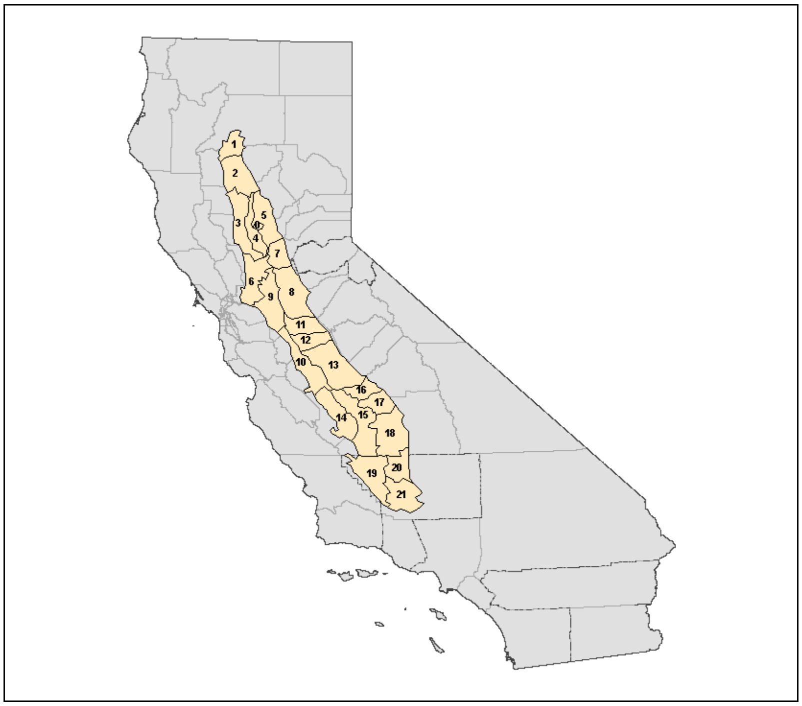

Figure 3.6.1. California agricultural regions as CVPMs.

Production costs and inputs are five years (1999-2004) averages and correspond to those used in a recent SWAP study for historic hydrology for climatic change (Medellin-Azuara, et al., (In Press)). Six CVPMs are part of this study namely, 10, 14, 15, 18, 19 and 21.

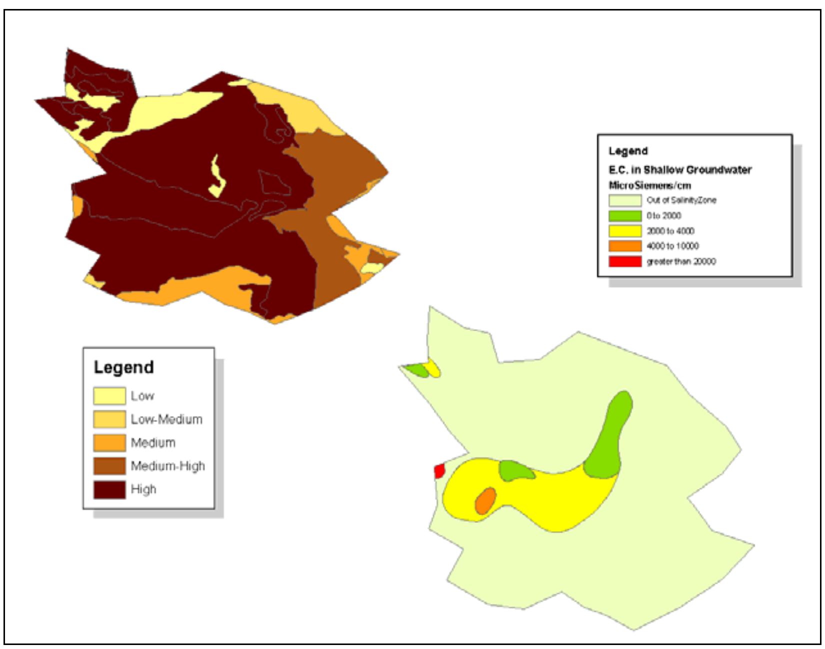

Figure 3.6.2. Soil capacity class (left) and electrical conductivity in shallow Groundwater (right) at CVPM 21 (Sources: Surgo and Bureau of Reclamation).

Table 3.6.6. Crop distribution by salinity zone at CVPM 21 (Source DWR).

	Salinity Zone (figures in µS/cm)				
Crops	**Out Salinity Zone**	**0-2000**	**2000-4000**	**4000-10,000**	**Grand Total**
Alfalfa	41,992	12,838	12,967	318	**68,116**
Citrus	18,931	-	-	-	**18,931**
Cotton	63,567	7,047	59,542	3,843	**134,000**
Field Crops	29,362	9,472	14,273	405	**53,513**
Grains	39,147	4,916	16,206	449	**60,719**
Orchards	31,664	817	518	-	**32,998**
Pasture	1,146	578	28	-	**1,751**
Sugar Bet	859	-	60	-	**919**
All Grapes	52,558	978	161	-	**53,697**
Truck crops	55,420	330	2,288	599	**58,637**
Fallow Land	25,762	6,090	10,016	1,951	**43,819**
Grand Total	**360,408**	**43,067**	**116,059**	**7,565**	**527,099**

Salinity data was obtained from the DWR's San Joaquin Valley Drainage Monitoring Program. Georreferenced salinity data on shallow groundwater (Figure 3.6.3) was overlaid with CVPM land use surveys. Thus each of the CVPMs in the study were disaggregated into six electrical conductivity ranges, namely non-surveyed, 0-2000, 2000-4000, 4000-10,000, 10,000-20000, and greater than 20,000 µS/cm (Figure 3.6.3).

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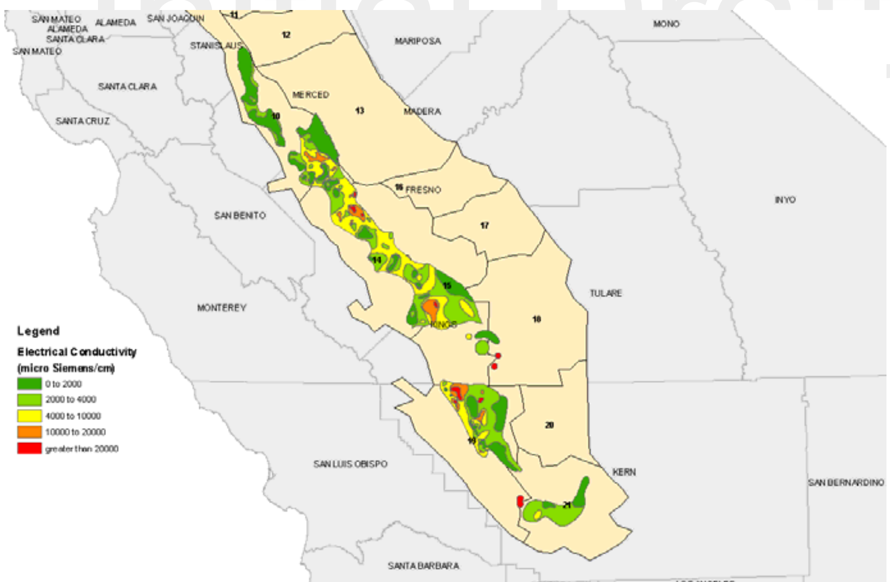

Figure 3.6.3. Salinity (as electrical conductivity) in shallow groundwater (Source: DWR).

3.6.5.2 Soil Class

Soil capacity class data corresponds to the Soil Survey Geographic (SSURGO) database (http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/), the aggregation level was the national database. A weighted average based on area was calculated for the parcels from the DWR surveys.

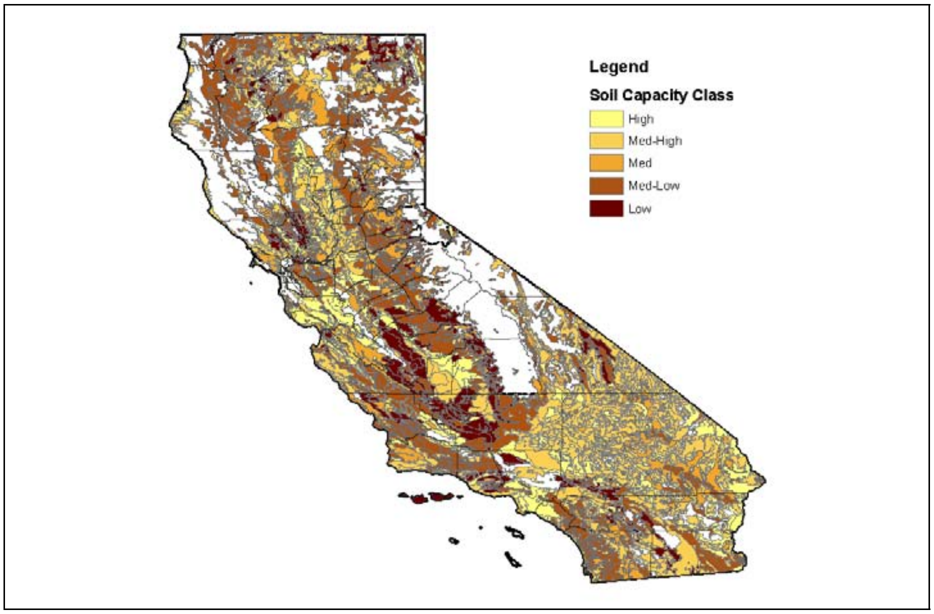

Figure 3.6.4. California Soil Capacity Class (Source: SSURGO).

3.6.5.3 Policy Experiment

In order to compare land use predictions and cropping patterns under deductive and inductive approaches; base land use at each salinity zone of the CVPM was used to calibrate the parameters of the non-linear profit maximization problem described in the previous section (equations 7 thru 10). From there, the policy experiment consisted in increasing the salinity zone to the next level for all zones (except if greater than 20,000 µS/cm). Likewise, for the inductive case the probability of observing a crop in the next salinity zone was estimated. The base acreage for both approaches before the policy experiment is the same.

Predicted cropping pattern out of each approach is then compared. Zones for consideration are cultivated areas those out of the salinity zone, and areas with electrical conductivities in shallow groundwater 0-2000, 2000-4000, 4000-10,000 and 10,000-20,000 µS/cm. Since the policy experiments increase salinity to the next level and collect changes in the extensive margin, a change in the latest salinity zone (above 20,000 µS/cm) are out of consideration in the study.

3.6.6 Comparison Results

Consistent with expectations, results for both deductive and deductive approaches predict small changes in acres at low levels of salinity and more pronounced changes at higher levels of salinity. In general for the lowest salinity zones, the deductive approach prescribes to farmers smaller changes in both absolute and relative acres (as a percent change from base acres). Conversely, changes in the extensive margin are the greatest using the deductive approach when the salinity zone is at it highest level.

An aggregate of cultivated land per crop and salinity zone for all CVPM is shown in Table 3.6.7. In the first column, the crop groups in the study at each salinity zone are described. The next column lists the aggregate base acreage for all crops at each salinity level. The third column provides absolute acreage for crops after the policy simulation which is a change of salinity level (as electrical conductivity) to the next level in SWAP/DAP. The absolute acres for the inductive approach are shown in the fourth and fifth columns. The next two columns show the percent change in absolute acres, whereas the last two columns provide offer two parameters to contrast both approaches. The first parameter, is a ratio deductive versus deductive on the predicted absolute acres which is column three divided by column five. The second is a similar ratio for changes in relative acres as column six over column seven. The numbers in bold at the bottom of these last two columns correspond to the weighted average (based on acreage share) of the ratios at each salinity level.

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Table 3.6.7. Changes in the extensive margin for all CVPMs per crop and salinity zone.

	Deductive Approach (SWAP) Cultivated Absoute Acres		Inductive Approach (M. Logit) Cultivated Absoute Acres		Relative Acres (Extensive Margin) Deductive	Relative Acres (Extensive Margin) Inductive	Ratio of Abs. Acre	Ratio of % ch. Acres
Crop	Out of Salinity	0-2000 µS/cm	Acres	0-2000 µS/cm	Abs(% ch Acres)	Abs(% ch Acres)	SWAP/Mlogit	SWAP/Mlogit
Alfalfa	277,289	276,980	277,289	470,813	0.11	69.79	0.59	0.00
Citrus	18,101	17,975	18,101	18,593	0.70	2.72	0.97	0.26
Cotton	448,574	449,397	448,574	736,929	0.18	64.28	0.61	0.00
Field	218,515	218,556	218,515	349,240	0.02	59.82	0.63	0.00
Grains	181,132	180,692	181,132	345,668	0.24	90.84	0.52	0.00
Orchards	453,582	452,033	453,582	203,115	0.34	55.22	2.23	0.01
Pasture	21,978	22,613	21,978	27,432	2.89	24.82	0.82	0.12
Sugar Bet	13,697	13,683	13,697	21,815	0.10	59.26	0.63	0.00
All Grapes	163,491	163,317	163,491	12,255	0.11	92.50	13.33	0.00
Truck	316,204	315,995	316,204	397,712	0.07	25.78	0.79	0.00
Total	**2,112,562**	**2,111,242**	**2,112,562**	**2,583,573**		*Weighted Average*	**1.97**	**0.01**
	0-2000 µS/cm	0-4000 µS/cm	0-2000 µS/cm	0-4000 µS/cm	Abs(% ch Acres)	Abs(% ch Acres)	Ratio Abs Acres	Ratio % Chang
Alfalfa	79,687	79,905	79,687	96,886	0.27	21.58	0.82	0.01
Citrus	567	609	567	691	7.43	21.94	0.88	0.34
Cotton	138,440	145,876	138,440	175,950	5.37	27.09	0.83	0.20
Field	60,938	60,108	60,938	62,826	1.36	3.10	0.96	0.44
Grains	46,609	50,826	46,609	58,296	9.05	25.07	0.87	0.36
Orchards	56,992	49,316	56,992	13,168	13.47	76.89	3.75	0.18
Pasture	11,679	11,637	11,679	10,560	0.36	9.58	1.10	0.04
Sugar Bet	6,337	6,223	6,337	9,999	1.81	57.79	0.62	0.03
All Grapes	9,539	4,886	9,539	616	48.78	93.54	7.93	0.52
Truck	95,264	94,306	95,264	79,096	1.01	16.97	1.19	0.06
Total	**506,053**	**503,691**	**506,053**	**508,089**		*Weighted Average*	**1.38**	**0.18**
	0-4000 µS/cm	000-10000 µS/cr	0-4000 µS/cm	000-10000 µS/cr	Abs(% ch Acres)	Abs(% ch Acres)	Ratio Abs Acres	Ratio % Chang
Alfalfa	110,055	93,642	110,055	125,836	14.91	14.34	0.74	1.04
Citrus	546	366	546	856	33.06	56.61	0.43	0.58
Cotton	245,673	249,652	245,673	276,144	1.62	12.40	0.90	0.13
Field	69,954	59,268	69,954	64,199	15.27	8.23	0.92	1.86
Grains	92,470	91,682	92,470	103,468	0.85	11.89	0.89	0.07
Orchards	35,636	22,904	35,636	8,779	35.73	75.36	2.61	0.47
Pasture	6,511	5,725	6,511	5,704	12.07	12.39	1.00	0.97
Sugar Bet	12,251	11,769	12,251	17,903	3.94	46.13	0.66	0.09
All Grapes	3,092	2,435	3,092	139	21.24	95.49	17.48	0.22
Truck	115,760	105,426	115,760	91,492	8.93	20.96	1.15	0.43
Total	**691,948**	**642,869**	**691,948**	**694,520**		*Weighted Average*	**1.08**	**0.52**
	4000-10000 µS/cr	0000-20000 µS/c	000-10000 µS/cr	0000-20000 µS/c	Abs(% ch Acres)	Abs(% ch Acres)	Ratio Abs Acres	Ratio % Chang
Alfalfa	110,410	58,509	110,410	136,618	47.01	23.74	0.43	1.98
Citrus	858	180	858	1,062	79.06	23.77	0.17	3.33
Cotton	275,604	255,163	275,604	284,278	7.42	3.15	0.90	2.36
Field	39,571	24,205	39,571	30,418	38.83	23.13	0.80	1.68
Grains	90,483	70,062	90,483	95,757	22.57	5.83	0.73	3.87
Orchards	15,329	5,175	15,329	4,235	66.24	72.38	1.22	0.92
Pasture	4,931	1,773	4,931	4,772	64.04	3.24	0.37	19.78
Sugar Bet	20,378	17,511	20,378	29,001	14.07	42.31	0.60	0.33
All Grapes	1,144	671	1,144	1	41.33	99.91		0.41
Truck	107,149	79,935	107,149	82,270	25.40	23.22	0.97	1.09
Total	**665,857**	**513,185**	**665,857**	**668,410**		*Weighted Average*	**0.80**	**2.29**

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For low levels of salinity, results indicate that the deductive approach is less responsive than the inductive one. One possible explanation is that Van Genuchten and Hoffman formulation and parameters make the yield reduction curve very flat at the low end of electrical conductivity. In contrast, high levels of salinity make responses at the extensive margin more notorious with the mathematical programming approach. This can be verified by comparing magnitudes of percent change in acres (columns six and seven in Table 3.6.7. When an agricultural zone changes from no salinity to low salinity (0-2000 µS/cm) and from low salinity to medium salinity (2000-4000 µS/cm), the deductive approach shows small percent changes in land use compared to the inductive approach. For the last two salinity levels (4000-1000 μS/cm and 10000-20000 μS/cm), the results show increased response in the deductive approach.

Table 3.6.8. Comparison of programing versus economtric approach.

	CVPM 10	**CVPM 14**	**CVPM 15**	**CVPM 19**
	Ratio of Abs. Acre	**Ratio of Abs. Acre**	**Ratio of Abs. Acre**	**Ratio of Abs. Acre**
Crop	SWAP/MNL	SWAP/MNL	SWAP/MNL	SWAP/MNL
Alfalfa	0.59	0.82	0.74	0.43
Citrus	0.97	0.88	0.43	0.17
Cotton	0.61	0.83	0.90	0.90
Field	0.63	0.96	0.92	0.80
Grains	0.52	0.87	0.89	0.73
Orchards	2.23	3.75	2.61	1.22
Pasture	0.82	1.10	1.00	0.37
S. Beet	0.63	0.62	0.66	0.60
Grapes	13.33	7.93	17.48	.
Truck	0.79	1.19	1.15	0.97
Total	**1.97**	**1.38**	**1.08**	**0.80**

Table 3.6.8 shows the correlation between the inductive and deductive methods of estimating crop salinity response. The closeness of the predictions is measured by calculating the ratios between the methods. A ratio value of one indicates complete consistency. Table 3.6.8 shows that the ratios for absolute acres are close to the unitvalue, with a global weighted average of 1.54. This indicates that on average, the predicted absolute acres by SWAP are greater than those predicted in the multinomial logit approach. The opposite occurs for the ratio of percent changes in land use which is roughly 0.5 for all crops and salinity levels.

3.7 Direct Economic salinity costs for irrigated agriculture (2030)

3.7.1 Model Assumptions

Having performed a calibration test using econometrics for the programming model of this study (SWAP), salinity projections for 2030 were incorporated as part of the assessment. This section describes the steps undertaken to account for 2030 demand projections, price and expected salinity accumulation.

Three elements underlie the estimated costs of salinity for irrigated agriculture by year 2030. These elements are land conversion from agriculture to other uses, endogenous prices and salinity accumulation towards year 2030. However, revenue losses shown below are after demand and land use changes have taken place. Parameters in the production function take into account the estimated yield reduction following the van Genuchten and Hoffman (1984) formulation.

Land conversion follows Landis and Reilly (2002) study for California. Percent of land converted from agriculture by 2030 averages 10 percent for all CVPMs in the Valley. However some of the CVPMs forfeit more than 30 percent of their total land for non-farm uses.

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Demand projections and endogenous prices follow the procedures described in Medellin-Azuara et al. (2007). However, demand shifts and land conversion projections were scaled to year 2030 as two-thirds of the 2050 projection. Demand shifts take into account income projections for California, income elasticity of demands for agricultural products, agricultural imports vs. exports among some other considerations. Price volatility of each crop group was assumed the same for all CVPMs. However; prices of crop groups, factor costs and input usage were disaggregated at the CVPM level. A weighted price for each crop was estimated. Year 2030 prices for each crop group are the product of a non-linear optimization program to maximize producer's surplus in the central valley for each crop and CVPM. It was assumed that the 2030 crop prices at the CVPM level are the same within the CVPM.

3.7.2 Model Results

Estimated changes in agricultural land use and revenue losses are shown in the tables below.

Table 3.7.1. Percent change in land by crop groups in the saline CVPMs (7% saline land change).

CVPM	Alfalfa	Citrus	Cotton	Field Crops	Grains	Orch.	Pasture	Sugar beet	All Grapes	Truck Crops
10	-0.06	-0.11	-23.60	185.59	-57.81	-0.37	-2.30	0.17	-0.20	-0.15
14	-4.56		-5.53	-35.46	-12.96	-1.45	6.37	-4.43	-0.86	-1.12
15	-10.54	0.36	-12.00		40.57	-0.28	-4.96	-0.96	-0.16	-0.15
19	-0.81	0.46	-0.53	-15.26	-32.01	-0.52	-9.81	-0.67	-0.18	-0.10
21	0.39	-0.09	-6.07	-0.50	-24.63	-0.09	1.59		-0.03	-0.02

With some exceptions, most of the crop groups show reductions in acreage with respect to the 2030 base land use patterns. Grains and field crops seem to be the crop groups that are most affected by salinity accumulation.

Table 3.7.2. Total revenue losses in thousands of dollars per crop group for saline CVPMs.

CVPM	Alfalfa	Citrus	Cotton	Field Crops	Grains	Orch.	Pasture	Sugar beet	All Grapes	Truck Crops
10	-979	-15	-25733	17599	-3061	-1010	-744	28	-35	-618
14	-3439	0	-35869	-4727	-15918	-9717	55	-1318	-2408	-17616
15	-13109	-8	-35782	3671	4494	-2481	-406	-180	-1149	-180
19	-1229	-8	-1372	-2562	-15542	-1027	-314	-63	-343	-215
21	175	-65	-3959	-311	-6896	-90	2	0	-105	-136

Table 3.7.3. Revenue losses per acre in dollars per crop group for saline CVPMs

CVPM	Alfalfa	Citrus	Cotton	Field Crops	Grains	Orch.	Pasture	Sugar beet	All Grapes	Truck Crops
10	-8	-12	-243	1060	-383	-11	-24	2	-16	-6
14	-43		-70	-113	-67	-73	2	-85	-77	-53
15	-78	-21	-145		163	-12	-57	-18	-13	-8
19	-10	-3	-6	-83	-164	-12	-91	-13	-17	-8
21	2	-4	-55	-5	-165	-2	12		-3	-2

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Total revenue losses and losses per acre in the tables above are mainly the result of a migrating agricultural production to land with lower yields, as would happen when salt accumulates. Nevertheless, cropping decisions are also influenced by market prices and land availability.

Impacts of salt accumulation per crop and CVPM region are shown in Tables 3.7.4 and 3.7.5. By 2030, the total revenue losses for all crops and saline regions in the Central Valley are $185 million with a minimum 7% saline salt area increment, and nearly $360 million for the 12% land area change projection. These losses are due merely to expansion in the saline area. The effect changes in price and land conversion have been isolated.

Results suggest that revenue losses are relatively high for salt tolerant crops such as cotton and alfalfa. However, the acreage of these crops is the main multiplier for the revenue losses, as cotton an grains account for more than 40% of the cultivated land for the regions of this study.

Table 3.7.4. Estimated revenues losses ($1000) per crop and CVPM(7% saline land change)

Crop	Regions					
	10	14	15	19	21	Total Revenue
Alfalfa	-979	-3,439	-13,109	-1,229	175	-18,582
Citrus	-15	0	-8	-8	-65	-96
Cotton	-25,733	-35,869	-35,782	-1,372	-3,959	-102,714
Field crops	17,599	-4,727	3,671	-2,562	-311	13,670
Grain	-3,061	-15,918	4,494	-15,542	-6,896	-36,922
Orchard	-1,010	-9,717	-2,481	-1,027	-90	-14,324
Pasture	-744	55	-406	-314	2	-1,407
Sugar Beet	28	-1,318	-180	-63	0	-1,533
All Grapes	-35	-2,408	-1,149	-343	-105	-4,041
Truck	-618	-17,616	-180	-215	-136	-18,765
Regional revenue	-14,569	-90,956	-45,128	-22,676	-11,385	-184,714

Table 3.7.5 Estimated revenues losses ($1000) per crop and CVPM (12% saline land change).

Crop	Regions					
	10	14	15	19	21	Total Revenue
Alfalfa	-14,805	-3,439	-19,162	-4,107	322	-41,190
Citrus	-32	0	-6	-52	-101	-193
Cotton	-24,476	-121,762	-68,387	-4,483	-20,594	-239,702
Field crops	23,966	-4,727	4,178	-10,108	-952	12,356
Grain	576	-15,918	5,926	-19,299	-5,835	-34,550
Orchard	-2,331	-10,881	-2,745	-2,775	-155	-18,886
Pasture	-5,075	55	-427	-2,790	2	-8,235
Sugar Beet	92	-1,867	-161	-170	0	-2,106
All Grapes	-74	-2,679	-1,281	-745	-169	-4,948
Truck	-1,301	-19,793	-134	-560	-226	-22,015
Regional revenue	-23,461	-181,011	-82,199	-45,089	-27,707	-359,467

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The weighted average revenue loss of salinity is shown in the Table 3.7.6below to be $51 per acre at a 7% change and $97 per acre at a 12 % change in area of saline land. The reader is cautioned that this is a preliminary estimate of the direct costs on farmers of salt accumulation. In addition, the indirect costs can be calculated by the REMI model, as can the impacts on employment.

Table 3.7.6 Estimates of net revenue losses per CVPM at 7% and 12 % area increases in saline land.

	Net Salinity Loss (@ 7%)	**Net Salinity Loss (@ 12 %)**
Region (CVPM)	**Loss- $ /Acre**	**Loss- $ /Acre**
10	29.46	-47.45
14	64.53	-128.43
15	63.29	-106.61
19	37.61	-74.78
21	27.41	-66.72
Weighted Average	$51.0 / acre	$97.33/acre

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3.8 The Indirect Economic Impacts of Salinity Accumulation

3.8.1 Regional Economic Models, Inc. (REMI)

The following description of the REMI model was adapted from REMI Policy Insight 9.5, Model Documentation, 2007 Regional Economic Models, Inc[7]

REMI Policy Insight is probably the most widely applied regional economic policy analysis model. Uses of the model to predict the regional economic and demographic effects of policies cover a range of issues; some examples include electric utility restructuring in Wyoming, the construction of a new baseball park for Boston, air pollution regulations in California, and the provision of tax incentives for business expansion in Michigan. The model is used by government agencies on the national, state, and local level, as well as by private consulting firms, utilities, and universities.

The original version of the model was developed as the Massachusetts Economic Policy Analysis (MEPA, Treyz, Friedlander, and Stevens) model in 1977. It was then extended into a model that could be generalized for all states and counties in the U.S. under a grant from the National Cooperative Highway Research Program. In 1980, Regional Economic Models, Inc. (REMI) was founded to build, maintain, and advise on the use of the REMI model for individual regions. REMI was also established to further the theoretical Model Documentation – Version 9.5 3 framework, methodology, and estimation of the model through ongoing economic research and development.

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3.8.2 Overview

REMI Policy Insight is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric, and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to wage, price, and other economic factors.

The REMI model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the specific model being used. The overall structure of the model can be summarized in five major blocks: (1) Output, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Wages, Prices, and Costs, and (5) Market Shares. The blocks and their key interactions are shown in Figures 3.8.1 and 3.8.1.

The Output block consists of output, demand, consumption, investment, government spending, exports, and imports, as well as feedback from output change due to the change in the productivity of intermediate inputs. The Labor and Capital Demand block includes labor intensity and productivity as well as demand for labor and capital. Labor

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[7] http://www.remi.com/downloads/documentation/Policy_Insight_9-5_Model_Documentation.pdf. {REMI, 2008 #89}

force participation rate and migration equations are in the Population and Labor Supply block. The Wages, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the wage equations. The proportion of local, interregional, and export markets captured by each region is included in the Market Shares block.

Models can be built as single region, multi-region, or multi-region national models. A region is defined broadly as a sub-national area, and could consist of a state, province, county, or city, or any combination of sub-national areas. Within a large, multinational currency zone such as the European Union, models of a national economy can be built using the same economic framework employed in regional models.

Single-region models consist of an individual region, called the home region. The rest of the nation is also represented in the model. However, since the home region is only a small part of the total nation, the changes in the region do not have an endogenous effect on the variables in the rest of the nation.

Multi-regional models have interactions among regions, such as trade and commuting flows. These interactions include trade flows from each region to each of the other regions. These flows are illustrated for Model Documentation – Version 9.5 7 a three-region model in Figure 3.8.1.3.

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Multiregional national models that encompass an entire currency union, such as the U.S. or E.U., also include a central bank monetary response that constrains labor markets. Models that only encompass a relatively small portion of a currency union are not endogenously constrained by changes in exchange rates or monetary responses.

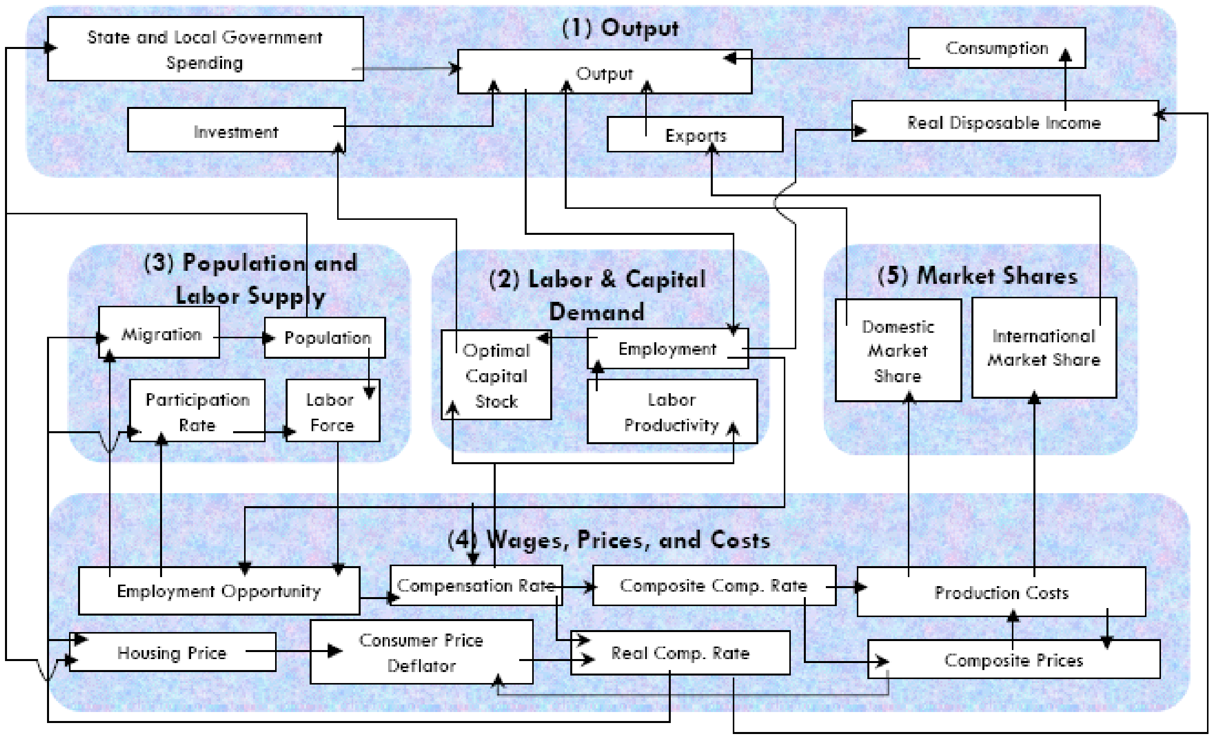

Figure 3.8.1. REMI model linkages.

3.8.2.1 Block 1. Output

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This block includes output, demand, consumption, investment, government spending, import, commodity access, and export concepts. Output for each industry in the home region is determined by industry demand in all regions in the nation, the home region's share of each market, and international exports from the region.

For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities, and population. Input productivity depends on access to inputs because a larger choice set of inputs means it is more likely that the input with the specific characteristics required for the job will be found. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

3.8.2.2 Block 2. Labor and Capital Demand

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity, and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

3.8.2.3 Block 3. Population and Labor Force

The Population and Labor Force block includes detailed demographic information about the region. Population data is given for age, gender, and ethnic category, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after tax wage rate. Migration includes retirement, military, international, and economic migration. Economic migration is determined by the relative real after-tax wage rate, relative employment opportunity, and consumer access to variety.

3.8.2.4 Block 4. Wages, Prices and Costs

This block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the wage equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods, and services.

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These prices measure the price of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs of distance is significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of outputs in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by the cost of labor, capital, fuel, and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying wage rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas, and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing prices change from their initial level depending on changes in income and population density.

Wage changes are due to changes in labor demand and supply conditions and changes in the national wage rate. Changes in employment opportunities relative to the labor force and occupational demand change determine wage rates by industry.

3.8.2.5 Block 5. Market Shares

The market shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and the effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

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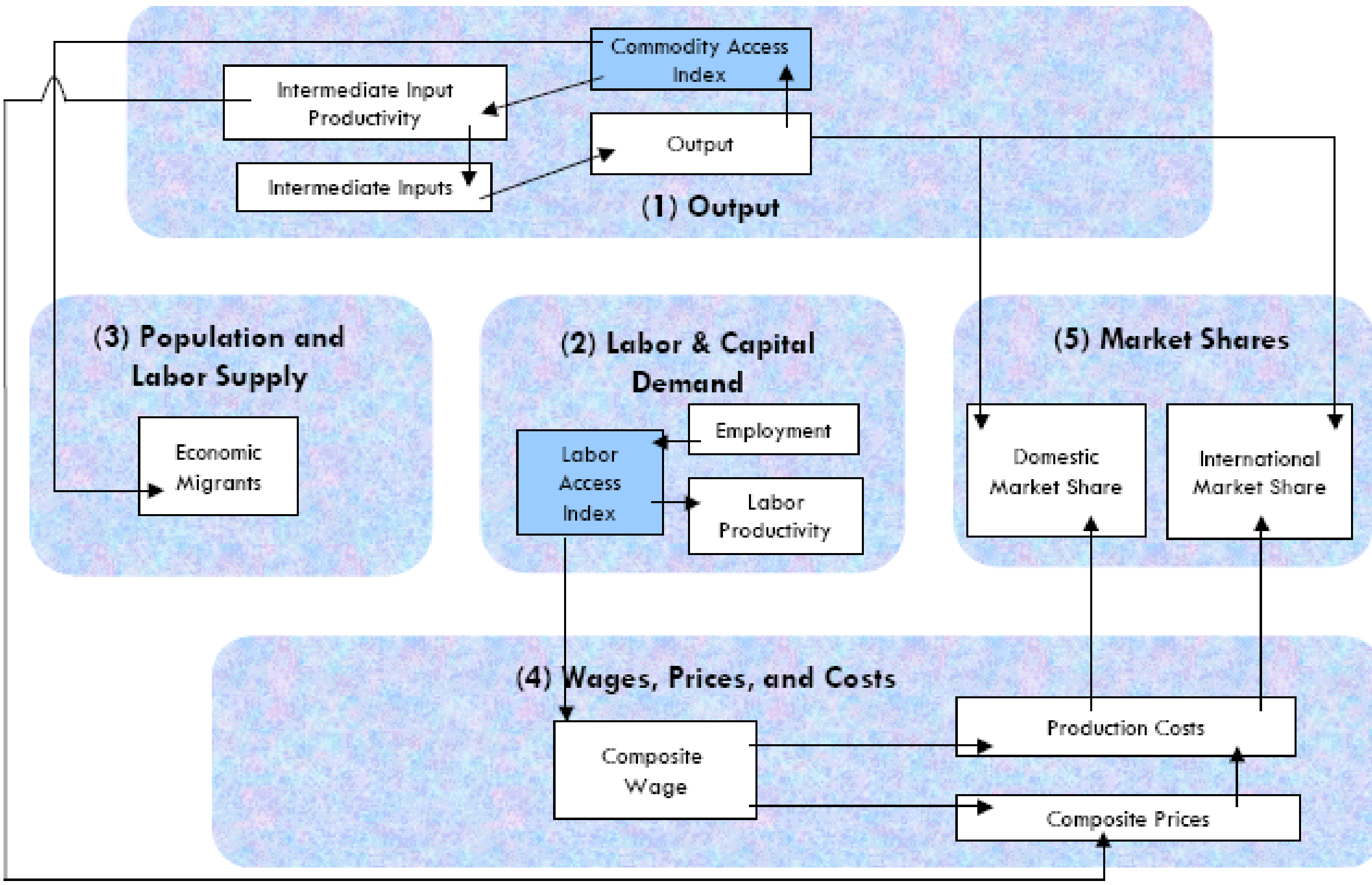

Figure 3.8.2 Economic Geography Linkages

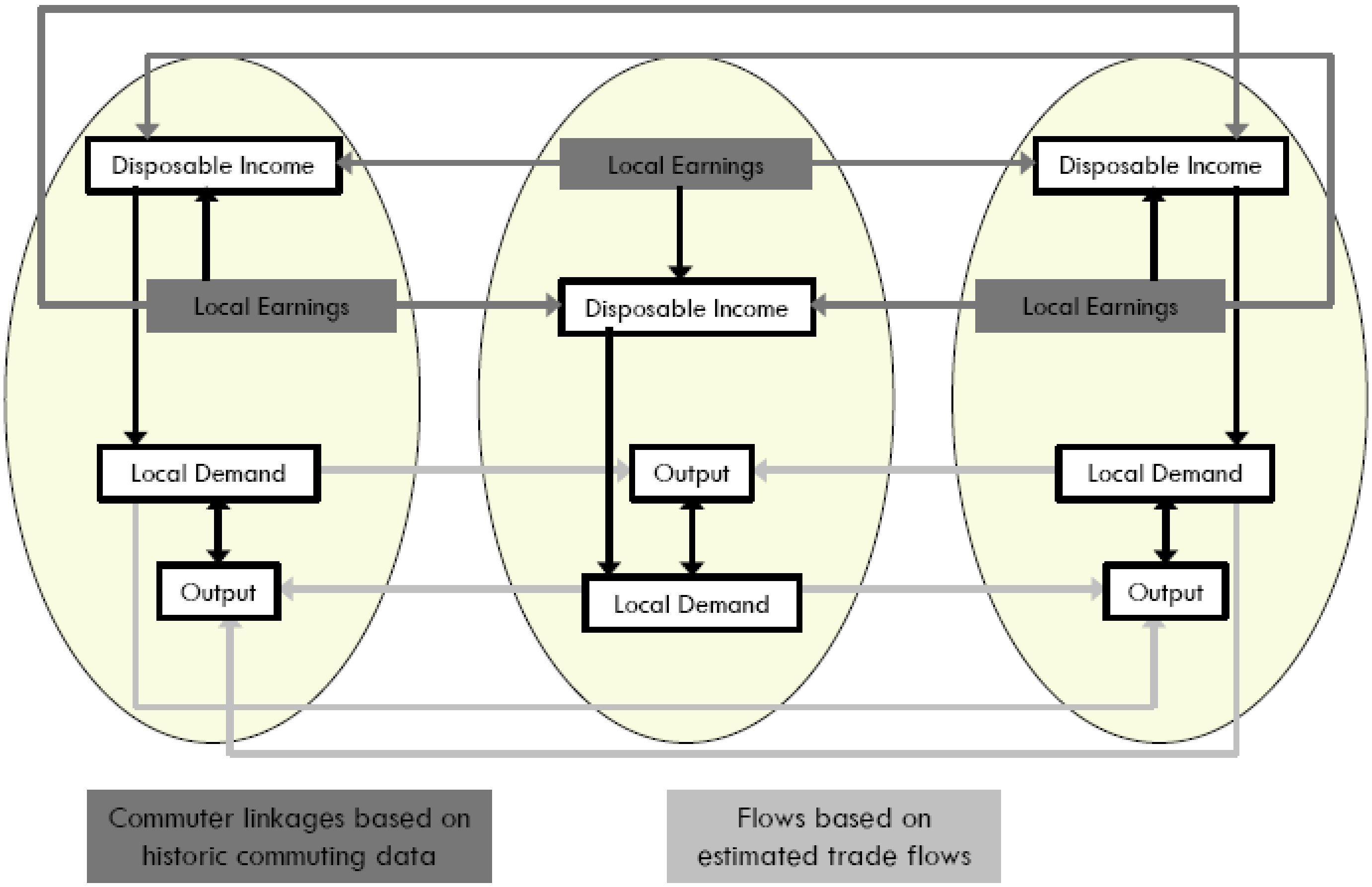

Figure 3.8.3. Trade and Commuter Flow Linkages.

3.8.3 Model Description

The first task in this section is to examine the internal interactions within each of the blocks and to present task is to examine the linkages between the blocks. Finally, the last task is to tie it all together by looking at the key inter-block and intra-block linkages.

The following block (Figure 3.9.4) incorporates the regional product accounts. It includes output, demand, consumption, government spending, imports, and exports. The commodity access index, an economic geography concept, determines the productivity of intermediate inputs. Inter-industry transactions from the input-output table are also accounted for in this block.

Output for each industry in the home region is determined by industry demand in all regions in the nation, the home region's share of each market, and international exports from the region. The shares of home and other regions' markets are determined by economic geography methods, explained in block 5.

Consumption, investment, government spending, and intermediate inputs are the sources of demand. Consumption depends on real disposable income per capita, relative prices, the income elasticity of demand, and population. Consumption for all goods and services increases proportionally with population. The consumption response to per capita income is divided into high and low elasticity consumption components. For example, the demand for consumer goods such as vehicles, computers, and furniture is highly responsive to income changes, while health services and tobacco have low income elasticities. Demand for individual consumption commodities are also affected by relative prices. Changes in demand by consumption components are converted into industry demand changes by taking the proportion of each commodity for each industry in a bridge matrix.

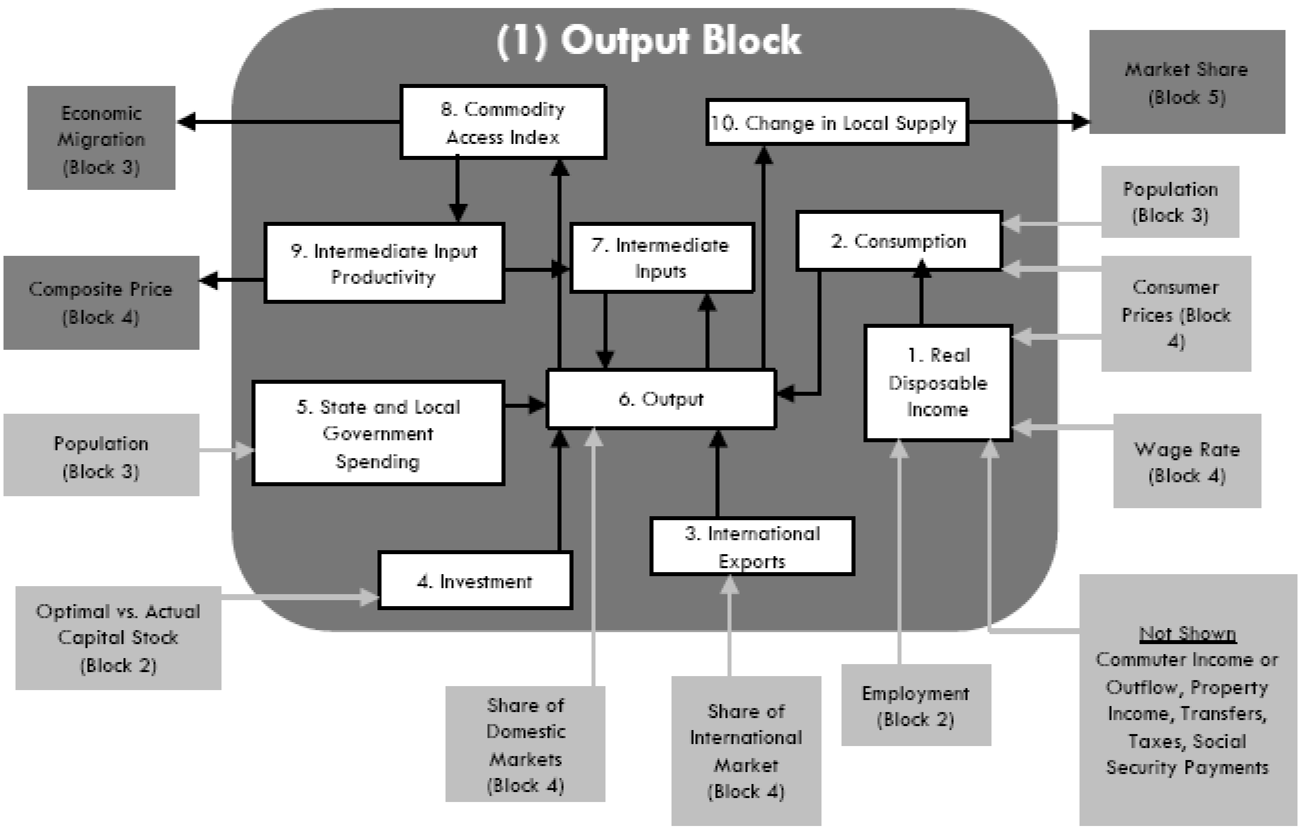

Figure 3.8.4. Key Endogenous Linkages in the Output Block.

Real disposable income, which drives consumption, is determined by wages, employment, non-wage income, and the personal consumption expenditure price index. Labor income depends on employment and the compensation rate, described in blocks 2 and 4, respectively. Non-wage income includes commuter income, property income, transfers, taxes, and social security payments. Disposable income is stated in real terms by dividing by the consumer price index.

Investment occurs through the capital stock adjustment process. The stock adjustment process assumes that investment occurs in order to fill the gap between the optimal and actual level of capital. The investment in new housing, commercial and industrial buildings, and equipment is an important engine of economic development. New investment provides a strong feedback mechanism for further growth, since investment represents immediate demand for buildings and equipment that are to be used over a long period of time. The need for new construction begets further economic expansion as inputs into construction, especially additional employment in this industry, create new demand in the economy.

Investment is separated into residential, nonresidential, and equipment investment categories. In each case, the level of existing capital is calculated by starting with a base year estimate of capital stock, to which investment is added and depreciation is subtracted for each year. The desired level of capital is calculated in the capital demand equations, in block 2. Investment occurs when the optimal level of capital is higher than the actual level of capital; the rate at which this investment occurs is determined by the speed of adjustment.

Government spending at the regional and local level is primarily for the purpose of providing people with services such as schooling and police protection. Thus, changes in government spending are driven by changes in population. The government spending equation takes into account regional differences in per capita government spending, as well as differential government spending levels across localities within a larger region.

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The demand for intermediate inputs depends on the requirements of industries that use inputs from other sectors. These inter-industry relationships are based on the input-output table for the economy. For example, a region with a large automobile assembly plant would have a correspondingly large demand for primary metals, since this industry is a major supplier to the motor vehicles industry.

Thousands of specialized parts are needed to assemble an automobile, and the close proximity of the parts suppliers to the assembly plant is particularly significant under just-in-time inventory management procedures. More generally, the location of intermediate suppliers is important to at least some extent for every industry. Thus, the economic geography of the producer and input suppliers is a key aspect of regional productivity.

The agglomeration economies provided by the proximity of producers and suppliers is measured in the commodity access index. This index determines intermediate input productivity. The commodity access index for each industry is determined by the use of intermediate inputs, the effective distance to the input suppliers, and a measure of the productivity advantage of specialization in intermediate inputs. This productivity advantage is the elasticity of substitution between varieties in the production function. Although producers may be able to find a substitute for the precise component or service that they desire, access to the most favorable input provides a productivity advantage. When substitution between varieties is inelastic, then the productivity benefit of access to inputs is high. Thus, agglomeration economies are strong for the production of electrical equipment, computers, and machinery, and other industries that require specialized types of inputs for which substitution is difficult.

An increase in the output of an industry provides a larger pool of goods and/or services from which to choose. Since firms incur some fixed cost to produce a new variety, this increased pool of goods and services represents an increased availability of varieties. Therefore, an increase in industry output leads to a greater supply of differentiated goods and services, which can in turn lead to higher productivity and increase output. This positive feedback between tightly related clusters of industries is one source of regional agglomeration.

Since standard input-output analysis is often used to predict the effect of a firm either moving into or out of an area, it is important to explain why the results of the input-output analysis is incomplete. The following diagrams and explanation give an overview of the differences and similarities between REMI Policy Insight and standard Input-Output.

Some input-output models differentiate consumption by average household spending rates based on average earnings by industry. REMI differentiates between changes in income per capita and income changes due to changes in population, and includes different income elasticities for purchases of different consumer products (e.g. the consumption type that includes cigarettes has a lower income elasticity than the type that includes motor vehicles). Also, most I-O models would not account for the inflow and outflow of commuters.

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Thus, the I-O model captures the inter-industry flows that occur as output changes (each extra dollar of steel used 3 cents of coke) and it has feedbacks to consumer spending that are generated by changes in workers' income. Since population migration changes are not modeled, feedbacks to state and local governments in terms of new demands for per capita services are not included. Investment spending to construct new residential housing and commercial buildings cannot be modeled in static input-output models, because it is a transitory process that will occur when the need for housing and new stores occurs due to higher incomes and population but will return towards the baseline construction activity once the number of new houses and stores has risen enough to meet the one-time permanent increase in demand.

The change in the share of all markets as costs, the access to intermediate inputs, and the access to labor and feedback from other areas in a multi-region model are not included in standard I-O models. These all have effects in the short run, but the effects are even much larger in the long run. While an I-O analysis just gives a partial static picture, REMI catches all of the dynamic effects for each year in the future.

In addition to the difference in the extent of the important feedbacks in REMI compared to I-O, there is a major difference in the options for inputting policy variables in the two models.

Standard input-output models only account for the direct output changes entered into the model, neglecting the displacement effects or augmenting effects on similar businesses in the region (or regions) modeled (small dashed blocks). REMI also provides this option.

Only REMI provides for inputting the output of the new firm in a way that accounts for displacement of competing employers in the home region and other regions in the multi-region model (large dashed blocks).

The alternative way that REMI provides for the effect of a firm entering or leaving a region due to a policy change can have substantial effects on the predicted outcome. For example, if a new grocery store is subsidized to move in, but 95% of all groceries are bought in the home region in the baseline case, then most of the sales of the new firm would displace sales in the grocery stores that are currently in the home region. This would mean that the net increase in jobs would only be a fraction of the firm's employment. The gain would mainly have to come from the increasing share in other regions, and this may be small if the initial shares indicate that the geographic area served by this industry is always very close to its source. In addition to considering the initial displacement, the REMI policy variable for a new firm will show how the future will be different if this new firm maintains its initial gain in share in the multi-region, the rest of the monetary union, and the rest of the world markets. Thus, the long-term effects will capture the differential effects of gaining share in an industry in which demand in the relevant markets is expanding rapidly versus those in which the demand is growing slowly. It will also capture the way that future projected changes in output per worker will mean that sales growth and employment growth may differ markedly.

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The range of other policy variables for the output block can be seen in the diagrams. These other ways that policy can influence the economic and demographic future of an area are not available for standard I-O models, because the linkages to most of the key processes that influence the outcomes in the region are not included in the structure of I-O models.

The Labor and Capital Demand block includes employment, capital demand, labor productivity, and the substitution among labor, capital, and fuel (Figure 3.9.7). Total employment is made up of farm, government, and private non-farm employment. Employment in private non-farm industries depends on employment demand and the number of workers needed to produce a unit of output. Employment demand is built up from the separate components of employment due to intermediate demand, consumer demand, local and regional government demand, local investment, and exports outside of the area. The employment per dollar of output depends on the national employment per dollar of output, the cost of other factors, and the access to specialized workers.

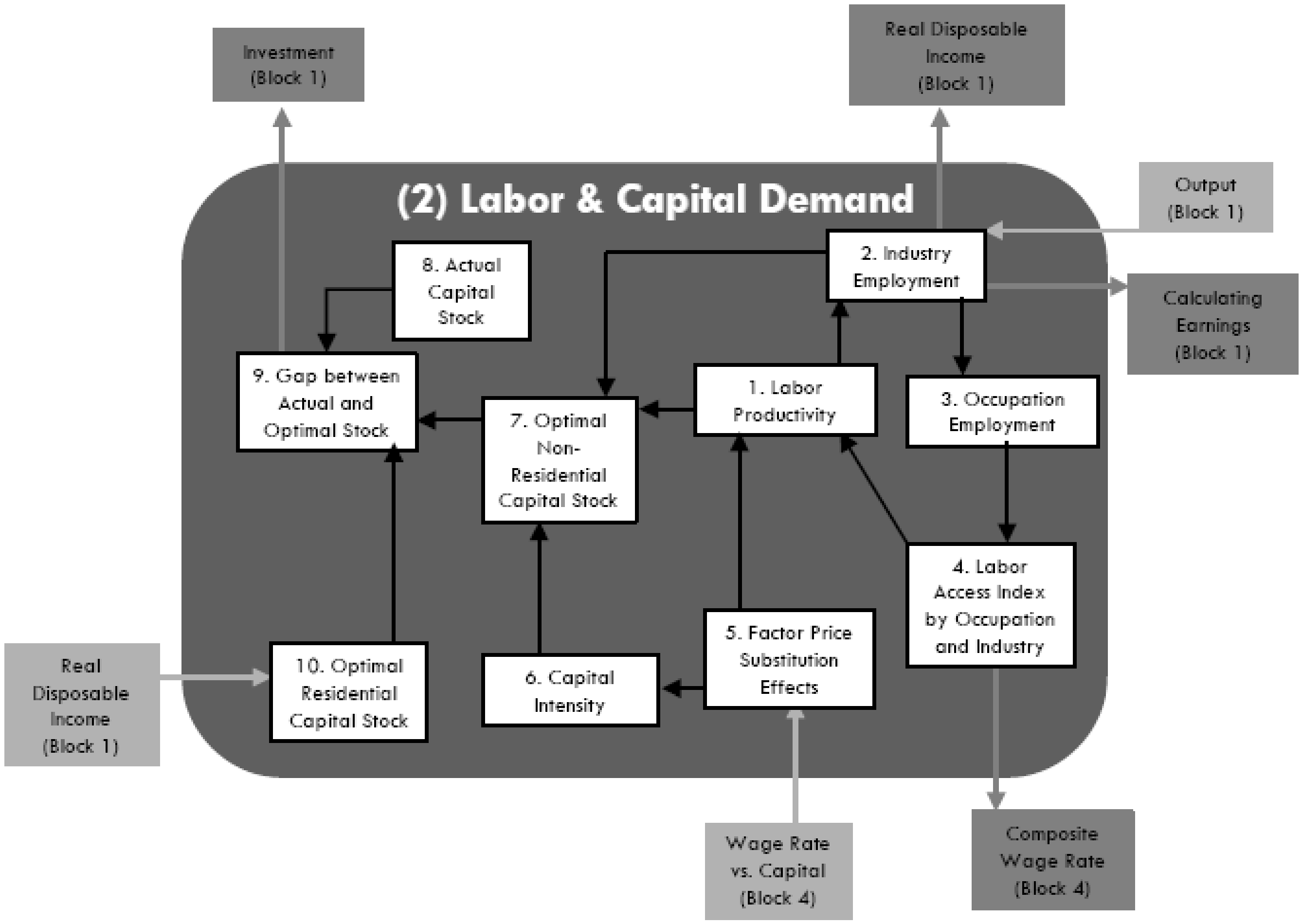

Figure 3.8.5. Block 2. Labor and Capital Demand

The availability of a large pool of workers within a region contributes to the labor force productivity. Each worker brings a set of unique characteristics and skills, even within the same occupational category. For example, a surgeon may specialize in heart, brain, or knee surgery. Although a brain surgeon may be able to perform a heart operation, the brain surgeon is likely to be less effective than a surgeon who has specific experience with heart surgery. Hospitals in major medical centers such as Houston are in an excellent position to meet their staff requirements because the number of qualified job applicants in the region is so large.

More broadly, locations that can be easily reached by a large number of potential employees can better match jobs with workers. The equation for labor productivity due to labor access is calculated separately for each occupation. Occupational productivity in each location is based on the residential location of all potential workers and their actual or potential commuting costs to that location.

The contribution of labor variety to productivity is measured by an occupation-specific elasticity of substitution based on a study that considered wages and commuting patterns across a large metropolitan area. While the match of workers in specialized roles that are consistent with their training has a large impact on productivity for medical occupations, it is significantly less important for workers in the food service sector. Industry productivity due to specialization is built up from occupational productivity, using the proportionate number of workers in each occupation that are employed by a given industry.

The number of employees needed per unit of output depends on the use of other factors of production as well as labor access issues. Labor intensity, which measures the use of labor relative to other factors, is determined by the cost of labor relative to the cost of capital and fuel. The substitution between labor, capital, and fuel is based on a Cobb-Douglas production function, which implies constant factor shares. Labor intensity is calculated for each industry.

Demand for capital is driven by the optimal capital stock equation for industries and for housing. The optimal level of capital is determined for non-residential structures and equipment for each industry. The regional optimal capital stock is based on the industry size measured in capital-weighted employment terms, the cost of capital relative to labor, and a measure of the optimal capital stock on the national level. The variable for employment weighted by capital use is determined by the capital weight, employment, and labor productivity. The capital weight is the ratio of industry capital to employment in the region compared to the capital to employment ratio for the nation. The national optimal capital stock is based on the investment in the nation, the actual capital stock, the speed of adjustment, and the depreciation rate.

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The optimal level of capital for residential housing is determined by the real disposable income in the region relative to the nation, the optimal residential capital stock for the nation, and the price of housing. To account for the cost of fuel, the fuel components of production (coal mining, petroleum refining, electric and natural gas utilities) are taken out of intermediate industry transactions and considered as a value-added factor of production. Then, firms substitute between labor, capital, and fuel (electric, natural gas, and residual fuel) as the relative costs of factor inputs change.

The Population and Labor Force block includes detailed demographic information about the region (Figure 3.9.8). The population is central to the regional economy, both as a source of demand for consumer and government spending and as the determinant of labor supply. As the composition of the population changes through births, deaths, and migration, so goes the region.

The demographic block is based on the cohort-survival method. Population in any given year is determined by adding the net natural change and the migration change to the previous year’s population. The natural change is caused by births and deaths, while migration occurs for economic and non-economic reasons. Population data is given for age, gender, and ethnic category.

Birth rates are the ratio of births to the number of women in each age group. The survival rate is equal to one minus the death rate, which is the ratio of deaths to population in each cohort. Since birth rates vary widely across age and ethnic groups, and survival rates vary widely for gender as well as age and ethnic category, the detailed demographic breakdown is needed to accurately capture the aggregate birth and survival rates.

Migration, economic or non-economic, also varies widely across population groups. Changes in retirement, international, and returning military migration are all assumed to occur for reasons that are not primarily due to with changing regional economic conditions. Retirement migration depends on the retirement-age population in the rest of the country for regions that have gained retirement population in the past, and on the retirement-age population within the regions for places that tend to have a net loss of retirees. The probability of losing or gaining a retiree is age and gender specific for each age group.

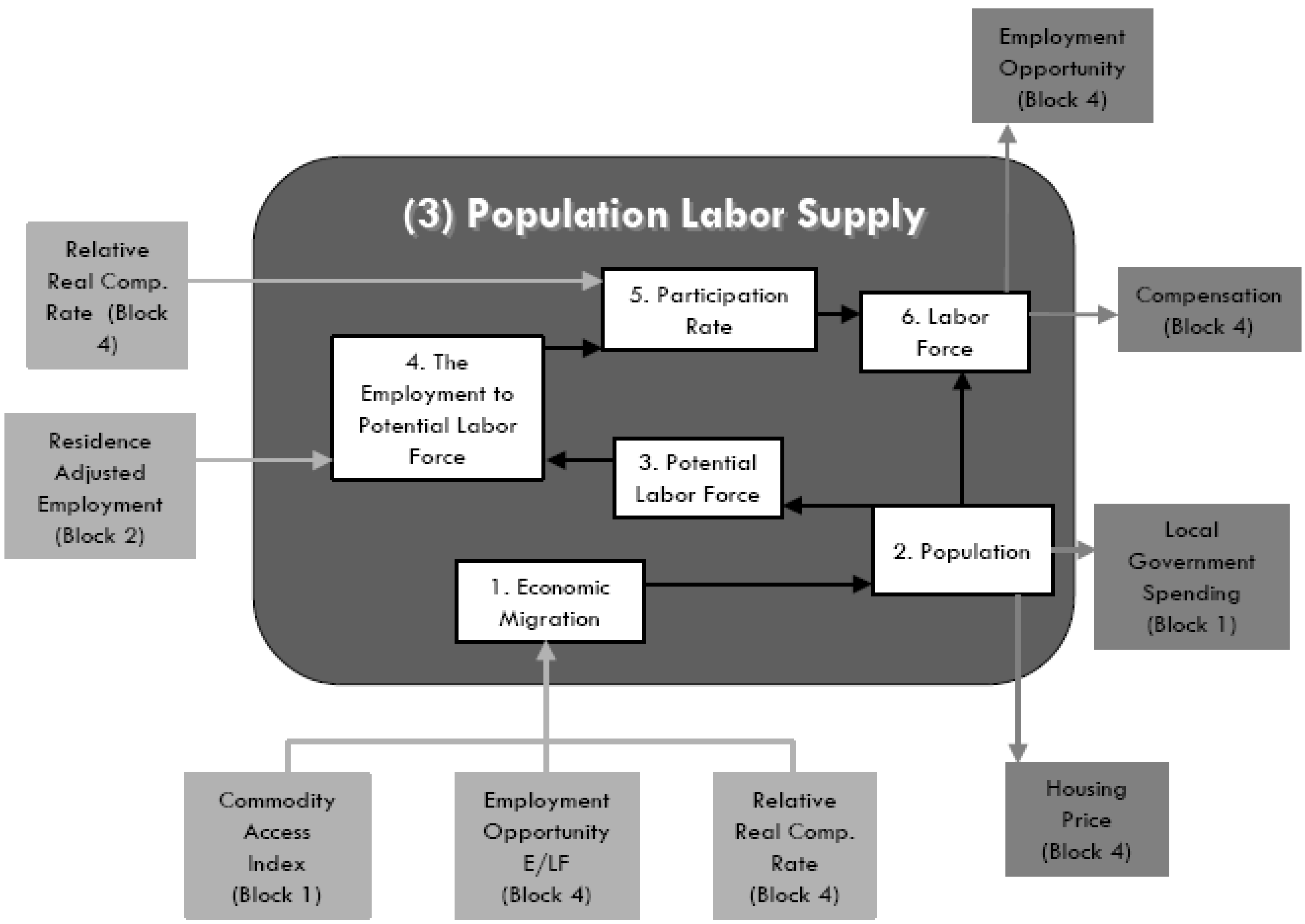

Figure 3.8.6. Block 3. Population and Labor Force.

International migration is also based on previous patterns. Changes in political restrictions on immigration and the economy of the immigrants' country are more significant in determining international migration than are changes in the economy of the home region. Returning military migration patterns are also better explained by existing patterns than by regional economic conditions, so returning military is also an exogenous variable.

Economic migration is the movement of people to regions with better economic conditions. Economic migrants are attracted to places with relatively high wages and employment opportunities. Migrants are also attracted to places with high amenities. Potential migrants value access to consumer commodities, which depend on economic conditions. Thus, as the output of consumer goods and services increases, the amenity attraction of the region increases. Other amenities are due to non-economic factors. These amenities or compensating differentials are measured indirectly by looking at migration patterns over the last 20 years. In this way, the compensating differential is calculated as the expected wage rate that would result in no net in or out-migration. For example, people may be willing to work in Florida even if paid only 85% of the average U.S. wage rate.

The labor force consists of unemployed individuals who are seeking work as well as employed workers. The labor force participation rate is thus the proportion of each population group that is working or looking for work. To predict the labor force, the model sums up the participation rate and cohort size for each demographic category. Participation rates vary widely across age, gender, and ethnic category; thus, the labor force depends in large part on the population structure of the region.

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The willingness of individuals to participate in the labor force is also responsive to economic conditions. Higher wage rates and greater employment opportunities generally encourage higher labor force participation rates. The extent to which rates change in response to these economic factors however, differs substantially for different population groups. For example, the willingness of men to enter the labor force is more influenced by wages, while women are more sensitive to employment opportunities.

This block includes wages, consumer prices, production costs, housing prices, and composite wages and input costs. Wages, prices, and costs are determined by the labor and housing markets. The labor market is central to the regional economy, and wage differences are the primary source of price and cost differentials between regions. Demand for labor, from block 2, and labor force supply, from block 3, interact to determine wage rates. Housing prices depend on changes in population density and changes in real disposable income.

Economic geography concepts account for productivity and corresponding price effects due to access to specialized labor and inputs into production. The labor access index from block 2, as well as the nominal wage rate, determines the composite wage rate. The composite cost of production depends on the productivity-adjusted wage rate of the region, costs of structures, equipment, and fuel, and the delivered price of intermediate inputs.

The delivered price of a good or service is based on the cost of the commodity at the place of origin, and the distance cost of providing the commodity to the place of destination. This price measure is calculated relative to delivered prices in all other regions, and weights the delivered price from all locations that ship to the home region.

The Market Shares block represents the ability of the region to sell its output within the local region, to other regions in the nation, and to other nations (Figure 3.9.10). Although the share of local markets is generally higher than any other market share, the equation for the market share of the home region is the same as for other regions within the nation. The share of international exports from the home region depends on national exports overall, and relative cost and output changes in the home region.

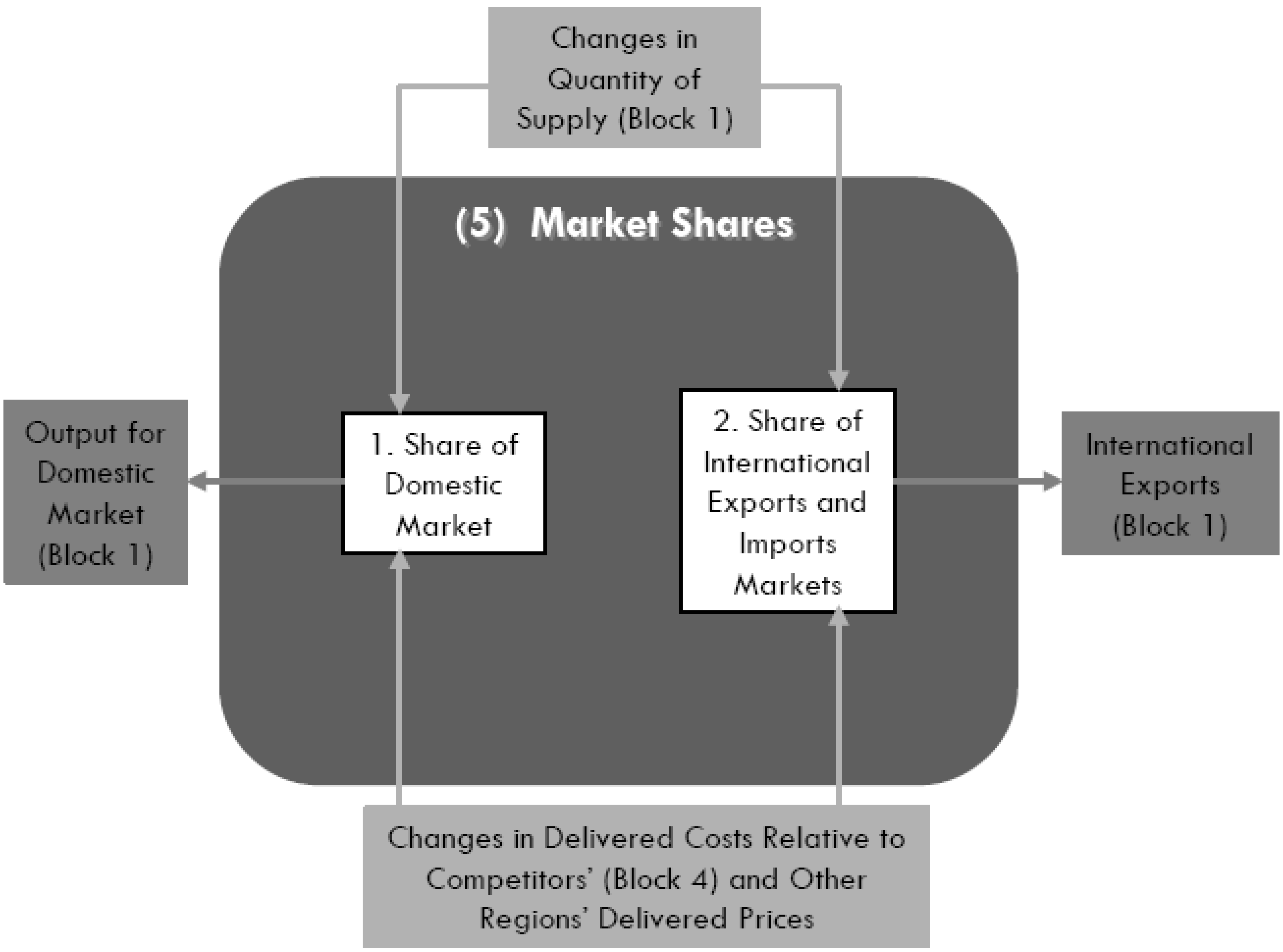

Figure 3.8.7. Block 5. Market Shares.

Changes in market shares within the nation depend on changes in industry production costs and output. Production cost increases lower market shares, but higher output raises market shares. Market shares rise with output increases, since higher output is better able to meet local and other regions' demand for goods and services by providing more choices.

3.8.4 The Central Valley REMI Model

REMI regions are configured as a county or by a group of counties. The Central Valley REMI Model was configured as a four region model made up of the Sacramento, San Joaquin and Tulare Basins, and the rest of California. The following maps delineate the Central Valley Regional Water Quality Control Board, the major hydrologic basins located in the Region, the counties related to that delineation, and final county-basin configuration.

It encompasses the hydrologic area drained by the Sacramento River, the San Joaquin River, and the hydrological closed area known as the Tulare Sub-basin. Those drainage areas form the basis of the three REMI regions.

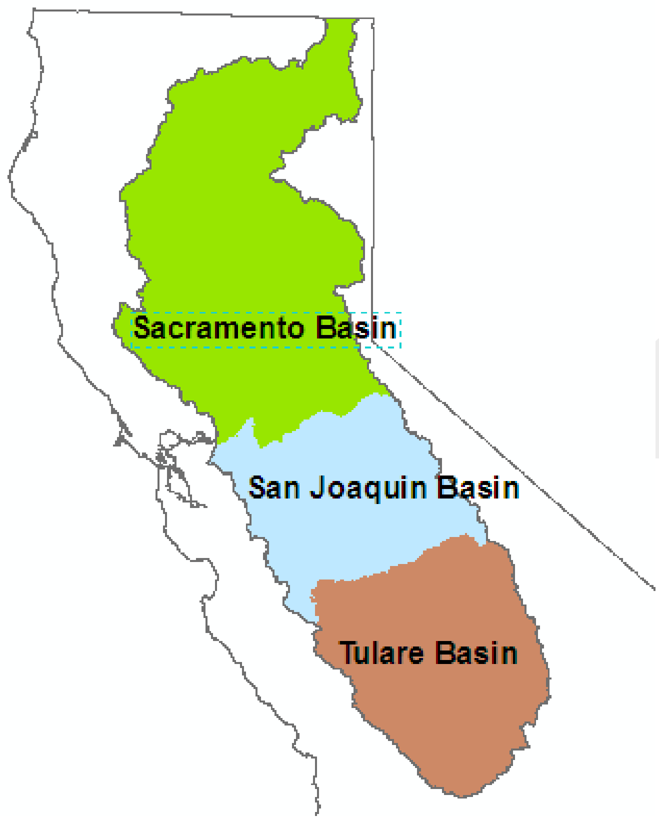

Figure 3.8.8. The Sacramento, San Joaquin and Tulare Basins of the Central Valley.

Determining the counties that represent the REMI region is important since counties are not delineated by hydrologic criteria. The California county map was overlaid on the Central Valley Basin map to select the counties that would represent the basins.From the overlay, it is evident that certain counties could or not be included in the basin designation. Siskiyou, Modoc, Lassen, Napa, Solano, Contra Costa and Kern counties have substantial areas inside and outside of the Central Valley delineation. Another problem is presented by Fresno County. Although located entirely within the Central Valley, it is divided between the San Joaquin and the Tulare Basins.

Since aggregations of county data represents each region, the effect of including or excluding each county needs to be assessed. Counties were included in the REMI model if a substantial portion of the counties population and economic activity was affected by the actions of the Central Valley Water Board.

The following map indicates the counties that were included in each Basin. The shaded areas outside of the Central Valley boundary indicate areas where county data are included in the Basin representation. Non-shaded area inside the Central Valley boundary represents areas where county data are not included in the Basin representation.

3.8.5 REMI Results

Total economic impacts of salinity accumulations were estimated using the REMI model described in an earlier section. Direct economic impacts were estimated for the three Basins included in this study and also reported in other sections on this report. This section presents a summary of the direct economic impacts, and detailed results from the REMI model.

3.8.5.1 Direct Economic Impacts

Sectors directly affected by salinity accumulations include households, manufacturing, wine production, food processing, confined animal operations and irrigated agriculture. Table 3.8.1 contains a summary of those sector cost and production changes for the three Basins in the Central Valley, and the corresponding REMI variables and data input units.

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Households purchase water softeners and replace salt damaged appliances and water pipes as salinity concentrations of water supplies increase. The additional consumer spending represents a positive economic impact but it is offset by a decline in other expenditures on other consumer items. REMI accounts for the this change in consumer spending patterns and it is based on historical expenditure patterns. The net effect is a slight decline in total economic activity with some sectors increasing and others declining.

Utilities and manufacturing will experience additional production costs due to higher salinity levels of their water supply. The cost of an increase in salinity concentration of one part per million was estimated to be $21.41 per acre foot for industrial water users. Total industrial water use was estimated by the Department of Water Resources for the three Basins. Total water use was allocated to industrial sectors on the basis of output. Actual costs of salinity increases were calculated by multiplying sector water use by $21.41 and the projected average basin increase in salinity concentration by 2030 (see section X.XX).

Production decreases in wine production, food processing, and confined animals due to probable regulation on salinity disposal were estimated and entered into REMI as reductions in output.

Impacts to Irrigated agriculture were characterized as reductions in commodity production due to increases in soil salinity.

Table 3.8.1. Direct Changes in Sector and Regional Economic Activity, 2008-2030

Sector REMI Variable	Units	Region	Direct Change 2008	2030
Household Cost Changes due to Increased Salinity Concentrations in Water Supply				
Consumer Spending (amount) Household Operation	2006 Chained National $ (M)	Sacramento	$2.150	$2.868
		San Joaquin	$1.705	$2.239
		Tulare	$1.380	$1.714
		Total	$5.235	$6.821
Industrial Production Cost Changes due to Increased Salinity Concentrations in Water Supply				
Production Cost (amount): by Utility and Manufacturing sector	2006 Fixed National $ (M)	Sacramento	$1.049	$14.423
		San Joaquin	$1.524	$15.379
		Tulare	$0.768	$11.333
		Total	$3.346	$41.135
Wine Production Changes due to Salinity Disposal Requirements				
Firm Sales (amount) Beverage,tobacco prod mfg	2006 Fixed National $ (M)	Sacramento	$0.000	-$7.446
		San Joaquin	$0.000	-$7.859
		Tulare	$0.000	-$2.365
		Total	$0.000	-$17.670
Food Processing Changes due to Salinity Disposal Requirements				
Firm Sales (amount) Food mfg	2006 Fixed National $ (M)	Sacramento	$0.000	-$12.357
		San Joaquin	$0.000	-$29.632
		Tulare	$0.000	-$27.778
		Total	$0.000	-$133.340
CAFO Production Changes due to Salinity Disposal Requirements				
Firm Sales (amount) Agriculture	2006 Fixed National $ (M)	Sacramento	$0.000	-$6.970
		San Joaquin	$0.000	-$66.647
		Tulare	$0.000	-$85.383
		Total	$0.000	-$159.000
Irrigated Agricultural Production Changes due to Increases in Soil Salinity				
Firm Sales (amount) Agriculture	2006 Fixed National $ (M)	Sacramento	$0.000	$0.000
		San Joaquin	$0.000	$0.000
		Tulare	$0.000	-$184.714
		Total	$0.000	-$184.714

3.8.5.2 Total Economic Impacts

Total economic impacts are characterized by changes in State and regional income, output (value of goods and services produced), employment and population. REMI estimates annual changes to the economy from direct impacts specified by year. Since the changes in direct impacts are linear from the 2008 level to 2030, only the 2030 results will be reported in this section. Annual changes will be reported in an appendix.

3.8.5.3 Income, Output, Employment and Population Changes

Central Valley salinity accumulations are projected to cause a $2.167 billion decline in California's value of goods and services produced by the year 2030 (Table 3.8.2) Income is expected to decline by $941 million, employment by 29,270 and population by 39,440. Figures 3.8.1 and 3.8.2 allow comparisons of the Basin data presented in Table 3.8.2.

Table 3.8.2. Total California and Regional Economic Impacts, 2030

Variable	Sacramento	San Joaquin	Tulare	Rest of CA	CA
Output (Bil Fixed 2000$)	-0.173	-0.256	-0.750	-0.988	**-2.167**
Income (Bil Fixed 2000$)	-0.048	-0.136	-0.546	-0.211	**-0.941**
Employment (Thous)	-1.193	-4.759	-19.160	-4.154	**-29.270**
Population (Thous)	-1.555	-5.540	-28.000	-4.340	**-39.440**

Tulare Basin will receive most of the economic impacts due to salinity aggregations with a income reduction of $545.7 million and an employment reduction of 19,160 jobs. This represents 58 and 65 percent of the total State impacts respectively. The areas outside of the Central Valley will also experience substantial economic impacts due to economic linkages of Central Valley firms to the rest of the State. While income and employment impacts in the Rest of CA are modest, the production of good and services is projected to decline by almost one billion dollars. Income, on the other hand, will only decline by $211.4 million since the Rest of CA industries affected are more energy and capital intensive than the Central Valley sectors affected by salinity accumulations.

Figure 3.8.9. California and Regional Income and Output Changes, 2030.

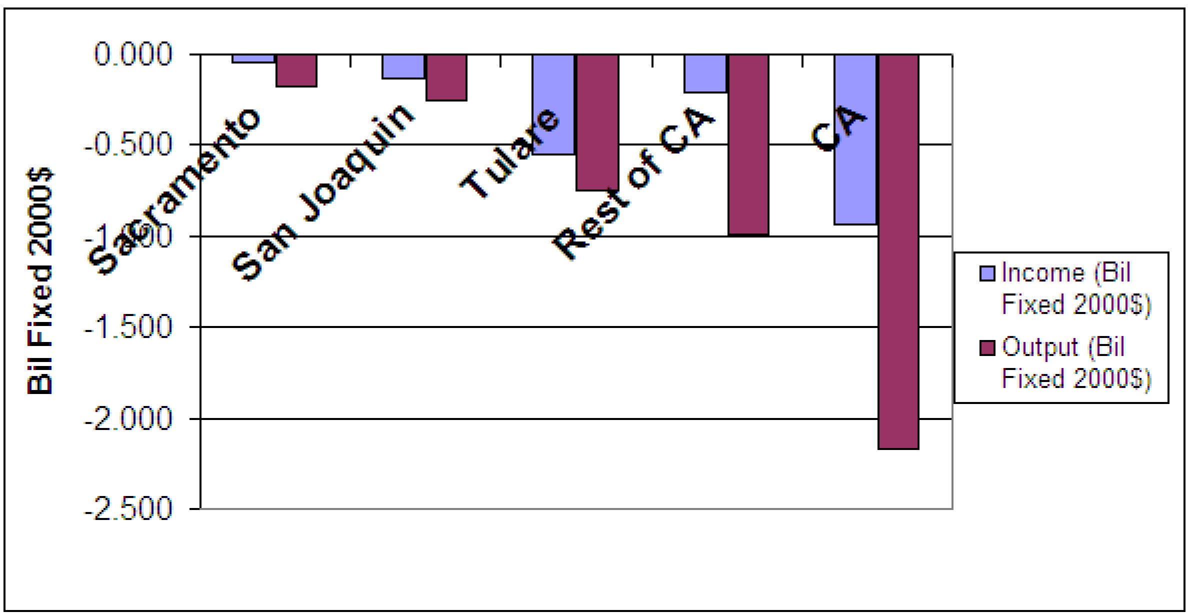

Figure 3.8.10. California and Regional Employment and Population Changes, 2030

California population is projected to decline by almost 40,000 people by 2030 with 28,000 of those losses occurring in the Tulare Basin. The Sacramento and San Joaquin Basins impacts are not as great as those projected for the Tulare Basin due to relatively small direct impacts to confined animal operations and none to irrigated agriculture.

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3.8.5.4 Population Changes by Race

Current California population is approximately 37 million[8]. The Sacramento Basin with 41 percent of the Central Valley's population is composed of 62 percent white and 18 percent Hispanic. This contrasts with the Tulare Basin where Hispanics comprise 49 percent of the population and whites only 40 percent. The racial composition of the San Joaquin Basin is closer to the racial composition of the State as a whole with 48 percent white and 32 percent Hispanic.

Table 3.1.5 and Figure 3.8.11 contain the 2030 projected change in population and racial composition of the Central Valley Regions. The California population is projected to increase to 46.6 million by 2030. This represents an average annual increase of 1.14 percent. The Sacramento Basin population is projected to increase to 4.8 million by 2030 or 33 percent, a 1.5 percent annual rate of growth. The white population is projected to decrease in California by 516 thousand (3 percent) and by 54 thousand (6 percent) in the Tulare Basin.

[8]REMI uses US Census population estimates and projection procedures. California Department of Finance estimates the State's population to be slightly higher.

Table 3.8.3. Percent Change in California and Regional Projected Population by Race, 2008-2030

Region	Sacramento	San Joaquin	Tulare	Rest of CA	California
White	18%	6%	-6%	-8%	-3%
Black	37%	24%	13%	7%	**12%**
Other	55%	46%	38%	47%	**47%**
Hispanic	69%	64%	47%	49%	**51%**
All Races	**33%**	**31%**	**24%**	**23%**	**25%**

Figure 3.8.11. Percent Change of the Regional Racial Composition of Central Valley Regions, 2008-2030

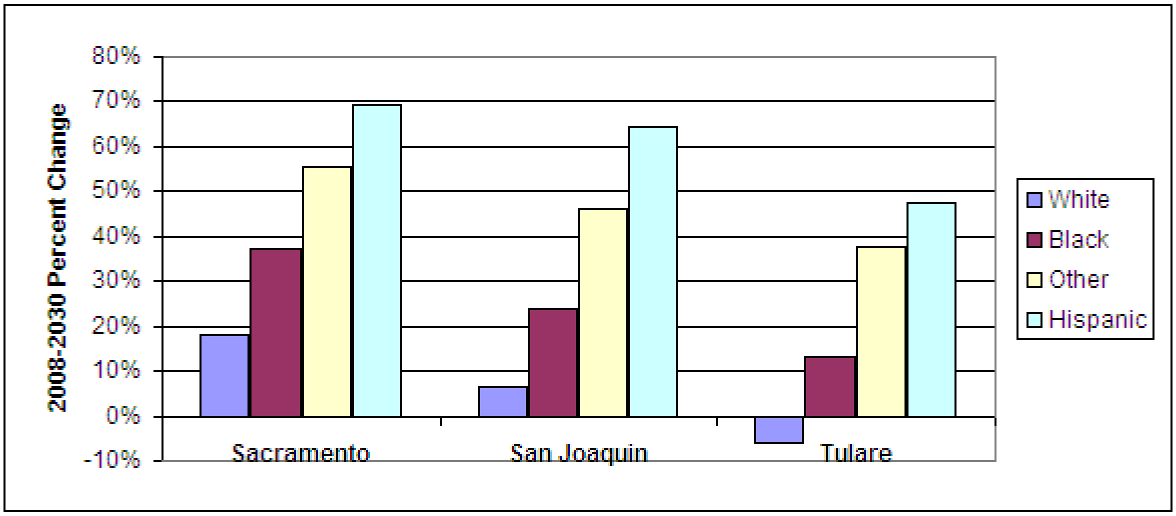


Table 3.8.4 presents a breakdown of the projected 2030 population changes by race. The Tulare Basin is projected to lose 28 thousand persons due to salinity aggregations by 2030 and 15,380 is expected to be Hispanic. The white population in the Tulare Basin is expected to decline by 9,438 by the year 2030 (Figure 3.8.12).

Table 3.8.4. Projected Change in California and Central Valley Regions Population by Race, 2008-2030

Region	Sacramento	San Joaquin	Tulare	Rest of CA	California
White	-0.912	-2.453	-9.438	-1.481	**-14.290**
Black	-0.092	-0.302	-0.869	-0.226	**-1.488**
Other	-0.236	-0.785	-2.318	-0.797	**-4.137**
Hispanic	-0.314	-1.999	-15.380	-1.838	**-19.530**
All Races	**-1.555**	**-5.540**	**-28.000**	**-4.340**	-39.440

Figure 3.8.12. Projected Change in California and Central Valley Regions Population by Race, 2008-2030

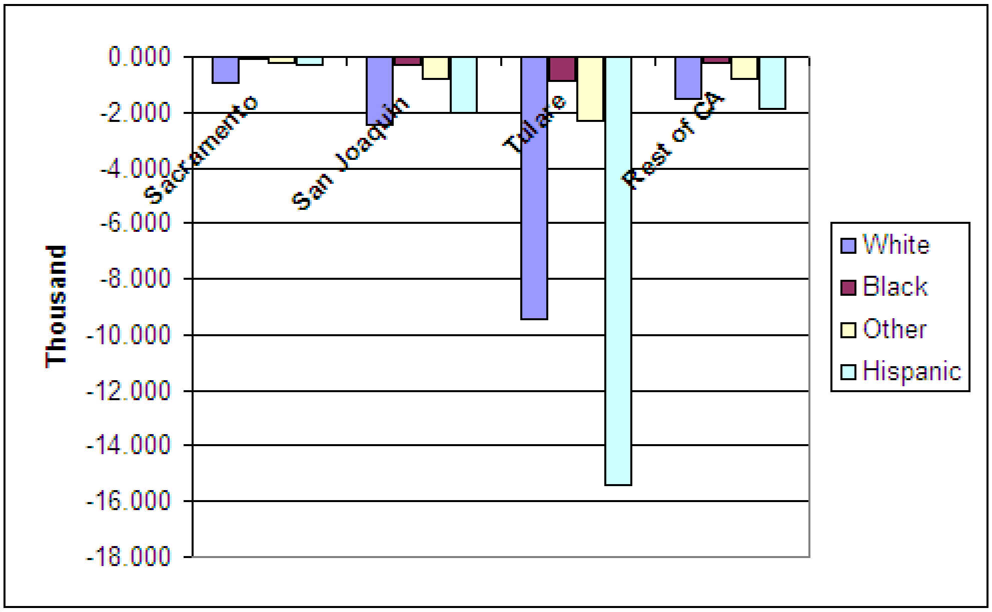
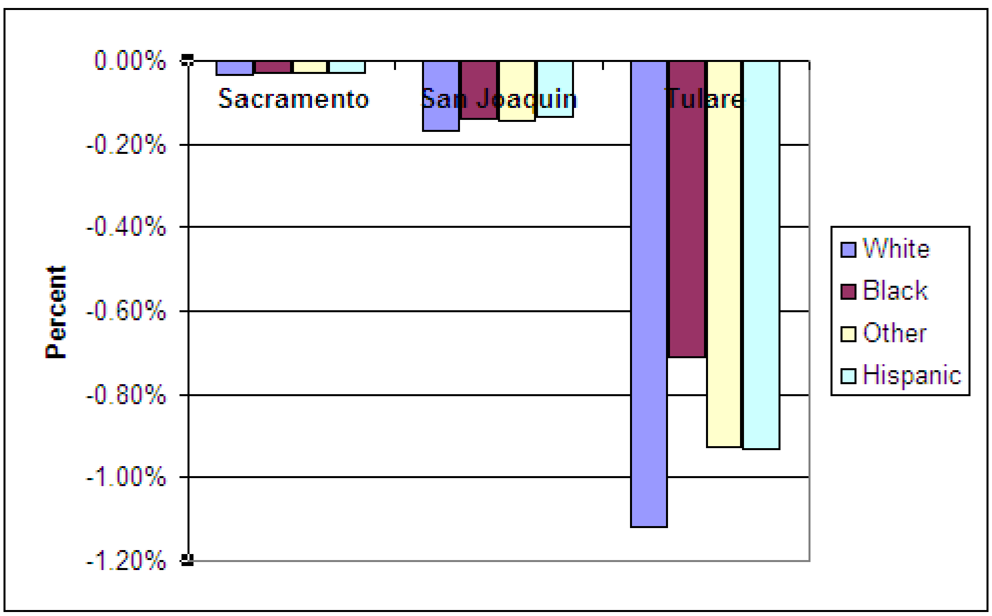


Figure 3.8.13. Projected Percent Change in Central Valley Regions Population by Race, 2008-2030



3.8.6 Sector Output Changes

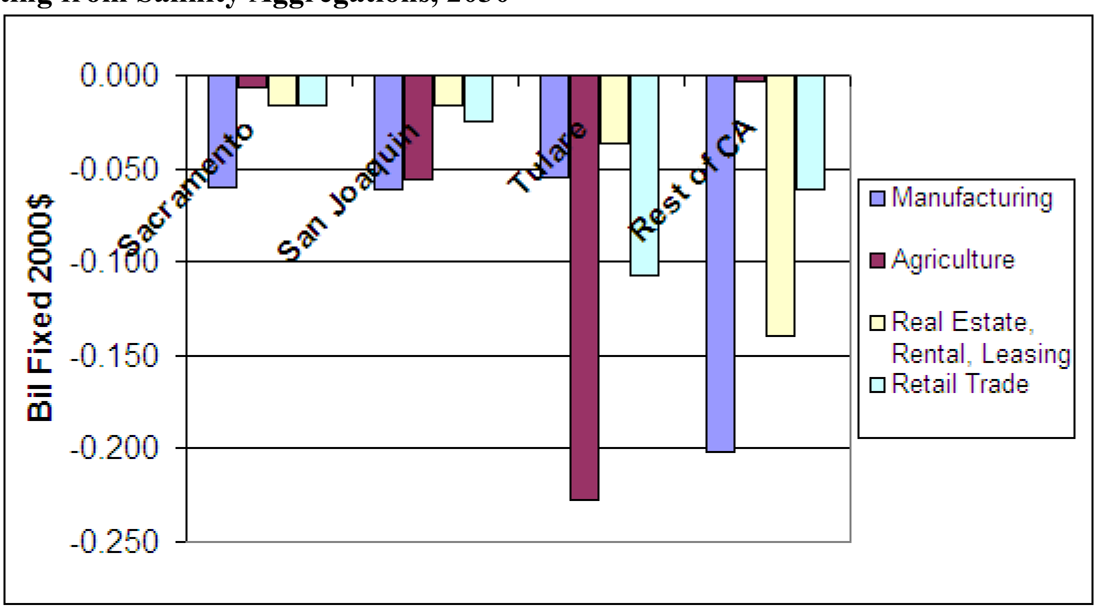
Over 45 percent ($.988 billion) of California's output losses ($2.167 billion) due to Central Valley salinity aggregations is expected to occur outside of the Central Valley (Table 8). The Tulare Basin is expected to lose $750 million in output while the Sacramento and San Joaquin Valley reduction are considerably less.

Table 3.8.5. Projected California and Regional Sector Output Changes Resulting from Salinity Aggregations, 2030

Sector	Sacramento	San Joaquin	Tulare	Rest of CA	CA
Manufacturing	-0.061	-0.061	-0.055	-0.201	-0.378
Agriculture	-0.006	-0.056	-0.228	-0.003	-0.294
Real Estate, Rental, Leasing	-0.017	-0.016	-0.037	-0.140	-0.209
Retail Trade	-0.016	-0.024	-0.107	-0.061	-0.209
Construction	-0.011	-0.022	-0.083	-0.039	-0.154
Profess, Tech Services	-0.008	-0.010	-0.025	-0.104	-0.148
Finance, Insurance	-0.011	-0.006	-0.015	-0.101	-0.133
Wholesale Trade	-0.009	-0.009	-0.032	-0.074	-0.124
Health Care, Social Asst	-0.007	-0.014	-0.067	-0.022	-0.110
Information	-0.006	-0.009	-0.012	-0.081	-0.108
Admin, Waste Services	-0.004	-0.004	-0.016	-0.032	-0.056
Accom, Food Services	-0.003	-0.004	-0.019	-0.023	-0.050
Other Services (excl Gov)	-0.004	-0.006	-0.022	-0.017	-0.048
Mngmt of Co, Enter	-0.003	-0.003	-0.005	-0.027	-0.038
Transp, Warehousing	-0.003	-0.003	-0.007	-0.022	-0.036
Arts, Enter, Rec	-0.002	-0.003	-0.008	-0.018	-0.030
Utilities	-0.002	-0.003	-0.013	-0.011	-0.029
Educational Services	-0.001	-0.001	-0.002	-0.009	-0.013
Mining	0.000	0.000	0.001	-0.001	0.000
Totals	-0.173	-0.256	-0.750	-0.988	-2.167

Figure 7 illustrates the relative output losses for manufacturing, agriculture, real estate and retail trade in the year 2030. These sectors represent the sectors with the greatest losses due to salinity aggregations. Agriculture is expected to lose $294 million in output with $228 million of that to occur in the Tulare Basin. Real estate and Retail trade sectors are projected to lose about $209 million by 2030. Retail trade in the Tulare Basin is expected to lose $107 million.

Figure 3.8.14. Projected California and Regional Output Changes for Selected Sectors Resulting from Salinity Aggregations, 2030



3.8.7 Manufacturing and Utility Output Changes

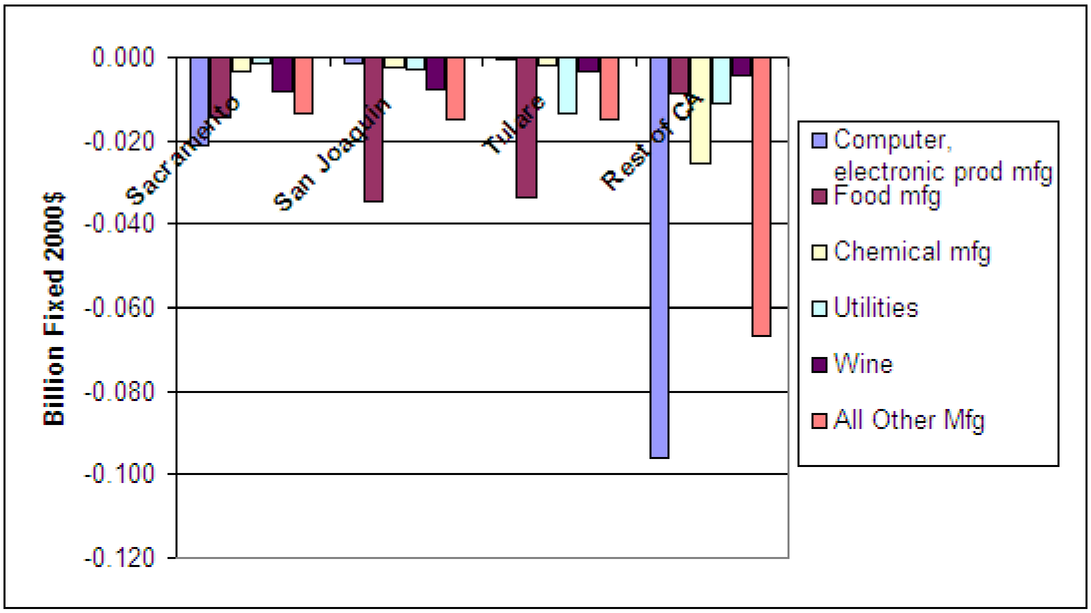
Manufacturing and utilities are large water users and will have to deal with the higher salinity concentrations in their water supply. The output losses for these industries are presented in Table 9 ranked in order of total California production. Computer and electronic manufacturing is expected to lose $120 million in output due to salinity accumulations which is somewhat surprising. However this industry is projected to increase from $285 billion in current output to 1,057 billion by 2030, a 271 percent increase. The Central Valley is expected to be an important part of this expansion with a projected 275 percent increase in the current output of $16.5 billion.

Table 3.8.6. Projected Industry Output Changes for California and Central Valley Regions, 2030

Industry	Sacramento	San Joaquin	Tulare	Rest of CA	California
Computer, electronic prod mfg	-0.021	-0.002	-0.001	-0.096	-0.120
Food mfg	-0.014	-0.035	-0.033	-0.009	-0.091
Chemical mfg	-0.003	-0.002	-0.002	-0.025	-0.033
Utilities	-0.002	-0.003	-0.013	-0.011	-0.029
Wine	-0.008	-0.008	-0.004	-0.004	-0.024
All Other Mfg	-0.013	-0.015	-0.015	-0.067	-0.110
Fabricated metal prod mfg	-0.002	-0.001	-0.002	-0.008	-0.013
Miscellaneous mfg	-0.001	-0.001	-0.001	-0.009	-0.012
Petroleum, coal prod mfg	0.000	-0.005	-0.004	-0.003	-0.012
Machinery mfg	-0.001	-0.001	-0.001	-0.008	-0.012
Plastics, rubber prod mfg	-0.001	-0.001	-0.002	-0.005	-0.009
Motor vehicle mfg	-0.001	-0.001	0.000	-0.005	-0.006
Furniture, related prod mfg	-0.001	-0.001	0.000	-0.005	-0.006
Nonmetallic mineral prod mfg	-0.001	-0.001	-0.001	-0.003	-0.006
Paper mfg	-0.001	-0.001	-0.002	-0.003	-0.006
Wood product mfg	-0.003	-0.001	0.000	-0.002	-0.005
Printing, rel supp act	-0.001	0.000	-0.001	-0.003	-0.005
Apparel mfg	0.000	0.000	0.000	-0.004	-0.004
Electrical equip, appliance mfg	-0.001	0.000	0.000	-0.003	-0.004
Transp equip mfg. exc. motor veh	-0.001	0.000	0.000	-0.002	-0.003
Textile prod mills	0.000	0.000	0.000	-0.002	-0.003
Primary metal mfg	0.000	0.000	0.000	-0.001	-0.002
Leather, allied prod mfg	0.000	0.000	0.000	0.000	0.000
Textile mills	0.000	0.000	0.000	0.000	0.000

The five industries with the largest losses in output were graphed in Figure 8 along with the remaining industries combined into one category to illustrate the relative output losses by region and industry. Computer and electronic output losses of $96 million are projected to occur outside of the Central Valley. The Sacramento Basin is expected to lose $21 million in output. Food processing is expected to incur losses of $35 million in the San Joaquin Basin and $33 million in the Tulare Basin. Tulare Basin utilities are projected to lose $13 million in output or about 47 percent of the total California loss. The relative large lose in other manufacturing sectors located outside of the Central Valley is an indication of the number and amount of the economic linkages in California's economy.

Figure 3.8.15. Projected Output Changes for Selected California and Central Valley Regional Industries, 2030



4 NON-MARKET ECONOMIC BENEFITS OF REDUCING SALINITY DISCHARGES

4.1 Central Valley Non Market Salinity Benefits

The San Joaquin Valley is a hub of business activity, urban and suburban development, and agricultural productivity. These aspects of Valley life, while beneficial in many ways, have for many years caused slow increases in the salinity (or saltiness) of surface water and groundwater in the region. When businesses, households, and farmers use water in the course of their everyday activities, often what is returned to the region's groundwater and surface waters has a little more salt and minerals than before it was used. This process occurs in all areas of the State, but unlike in most other areas of California, in large parts of the San Joaquin Valley used water does not flow to the ocean. Instead, it remains in the Valley, and is reused over and over as it is pumped from the ground and the surface to meet the region's water needs.

Relatively little is known about the effects of increasing salinity on Valley economic activity, and most of what is known is applicable to businesses and agriculture rather than to households and residents. To help provide more information about the effects of salinity on people who live in the Valley, and the economic importance of salinity management to them, the University of California conducted a mail survey of San Joaquin Valley households during 2007.

Initial Draft

The survey had several sections, the first of which asked about respondents' opinions and attitudes concerning different uses of water, how they themselves used water, and their opinions about their household water quality. Next, a series of questions asked about water-based recreational activities the household undertook in the San Joaquin Valley, and how they might change under different conditions. Respondents were then asked about their willingness to fund programs that would halt the increase in salinity of Valley waters. Another section asked about their preferences between salinity management programs that would differ in several key respects, depending on how the programs are organized and implemented. These include land in agricultural production, land areas devoted to wetlands, health outcomes measured by premature deaths from particulate air pollution, and household cost. These four key features are expected to vary depending on how salinity management plans are organized and implemented. A final section collected some basic demographic information about each respondent and their household, so that respondents to the survey can be compared to the general San Joaquin Valley and California populations, and their responses adjusted to more accurately reflect those populations.

This report is the first of several analyses to be conducted on the data collected in the survey, and summarizes all of the responses received. First we discuss the design and conduct of the survey. Then the responses to questions from the survey itself are presented and briefly explained.

4.2 Design of the Survey

With the help of a private sampling firm, a random sample of 1,000 households was selected. The San Joaquin Valley was divided into three geographic regions. The area north of Highway 182 was designated as Northern, the area between Highway 182 and Highway 198 was designated as Central, and the area south of Highway 198 was designed as Southern. Each of these regions was then divided into rural and urban. Rural areas are those 5-digit zip codes with populations of less than 50,000 people, and urban areas are those 5-digit zip codes with populations of more than 50,000 people. With these 3 geographic divisions and 2 demographic divisions, there were 6 groups in total, from which an equal number of households was selected.

Each household received a mailing consisting of a 12 page booklet, a 2 page insert, a cover letter explaining the survey's purpose and asking for the household's participation, and a postage-paid return envelope. For the first mailing (of 3 total), the packet included a dollar bill as both a token of appreciation and a signal of the survey's importance. The survey was conducted following the principles of the Total Design Method (Dillman, 1978).

As part of the survey development process, twenty-two focus groups and individual interviews were held to assess reactions to questions and information and clarity of the survey design. These were held in Davis, Modesto, and Fresno, during February and March of 2007. After completion of the focus groups, a pre-test survey was mailed to 150 randomly selected households in the San Joaquin Valley. The results and comments of these surveys were evaluated and used to improve the survey.

Initial Draft

The first survey mailing occurred on April 9, 2007, and a reminder postcard was sent approximately one week later. On April 18, 2007, a reminder letter accompanying a survey packet was mailed to those households whose surveys had not yet been received. The final mailing of survey packets took place on May 29, 2007.

Since a significant proportion of San Joaquin Valley residents speak Spanish in their homes, the letter accompanying the first round of surveys contained a sentence at the bottom written in Spanish, asking households to check the adjacent box if they would like a survey version in Spanish. For the next 2 mailings, Hispanic names were identified in the mailing list, and these households received both English and Spanish cover letters and surveys. In total, 20 households completed and returned Spanish versions of the survey.

Of the 1,000 surveys sent in the initial mailing, the postal service returned 51 due to an incorrect address or lack of a mail receptacle or because they were unclaimed. Seven family members returned surveys indicating that the addressee was deceased. The postal service returned an additional 40 surveys from the 2nd mailing and returned 15 from the 3rd mailing. Family members returned 5 surveys from the 2nd mailing, indicating that the addressee was deceased. A total of 389 completed surveys were returned, as well as 33 surveys that were blank, duplicates, or refusals to participate. The overall response rate, the percent of deliverable surveys returned, was about 44%.

Table 4.2.1.
Survey Response Rates (as of October 1, 2007) for the Total Population

	Number	Percentage of Total Mailed
Total Number Mailed	1,000	100%
Undeliverable Surveys		
Deceased	12	1.2%
Incorrect Address	96	9.6%
Unclaimed	6	0.6%
No Mail Receptacle	3	0.3%
Out of Town	1	0.1%
Surveys Delivered	882	88%
Surveys Returned		
Completed	389	39%
Duplicate Responses	2	0.2%
Incapable of Completing Survey	4	0.4%
Refused	15	1.5%
Returned with No Responses	12	1.2%
Response Rate (completed as percent of delivered)	44%	

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Table 4.2.2.
Response Rate by Region

	Percent Completed	Standard Deviation
North	47%	8.7
Central	44%	8.5
South	41%	8.4
Rural	42%	9.0
Urban	44%	11.7
North, Rural	49%	6.1
North, Urban	45%	6.1
Central, Rural	38%	5.3
Central, Urban	49%	6.5
South, Rural	36%	3.7
South, Urban	42%	7.5

4.3 Survey Results and Tabulations

The following sections briefly discuss each of the questions contained in the survey and present summaries of the responses received.

4.3.1 Section 1: Your Opinions about Water

The first section of the survey asks some general questions about participants' opinions on issues in the San Joaquin Valley, uses of water, and their own tap water. The survey contains these questions to gather information about households' views and beliefs and also to induce the respondents' reflection on what issues they think are important.

Given the significance of agriculture in the Valley, the survey begins with a question regarding the respondents' concern for protecting agriculture in the Valley. Almost two thirds of participants indicated that they are "extremely concerned," and 91% are at least "somewhat concerned" (Table 4.3.1).

Table 4.3.1. How concerned are you about protecting agriculture in the San Joaquin Valley?

Degree of Concern	Number	Percent
Extremely Concerned	248	65%
Somewhat Concerned	106	27%
Not too concerned	13	3.3%
Not at all Concerned	3	0.8%
No Response	19	4.9%
Total	389	100%

Initial Draft

The second question then asks about respondent's concern for the environment. 63% are extremely concerned, and 93% are at least somewhat concerned (Table 4.3.2).

Table 4.3.2. How concerned are you about protecting the environment?

Degree of Concern	Number	Percent
Extremely Concerned	243	63%
Somewhat Concerned	116	30%
Not too concerned	8	2.1%
Not at all Concerned	2	0.5%
No Response	20	5.1%
Total	389	100%

The third question reminds respondents that other issues, such as crime, health care, race relations, education, jobs, and the economy, may be important to them. For 53% of respondents, protecting agriculture is extremely important compared to these other issues, while 5% think it is not too or not at all important relative to these other issues (Table 4.3.3).

Table 4.3.3. Crime, health care, race relations, education, jobs, and the economy are some social issues that may concern you. Compared to these issues, how important is protecting agriculture?

Degree of Importance	Number	Percent
Extremely Important	204	52%
Somewhat Important	145	37%
Not too Important	16	4.1%
Not at all Important	3	0.8%
No Response	21	5.4%
Total	389	100%

The fourth question asks respondents to consider the importance of protecting the environment relative to other social issues. Fifty-five percent said protecting the environment is extremely important relative to these social issues while 4% indicated that it is not too or not at all important relative to the other issues (Table 4.3.4).

Table 4.3.4. Crime, health care, race relations, education, jobs, and the economy are some social issues that may concern you. Compared to these issues, how important is protecting the environment?

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Degree of Importance	Number	Percent
Extremely Important	210	54%
Somewhat Important	140	36%
Not too Important	16	4.1%
Not at all Important	2	0.5%
No Response	21	5.4%
Total	389	100%

The next set of questions asks respondents to consider various uses of water and how important each of these uses is to them. Figure 4.3.1 shows the ratings scale used, for which a value of 0 indicates that the issue is not important while a value of 5 indicates that the issue is very important. Figure 4.3.2 and Table 4.3.5 show the distribution of responses for different uses of water.

Table 4.3.5. Importance Scale for Uses of Water

Not Important					Very Important
0	1	2	3	4	5

Figure 4.3.2.
Respondents' Ratings of the Importance of Uses of Water

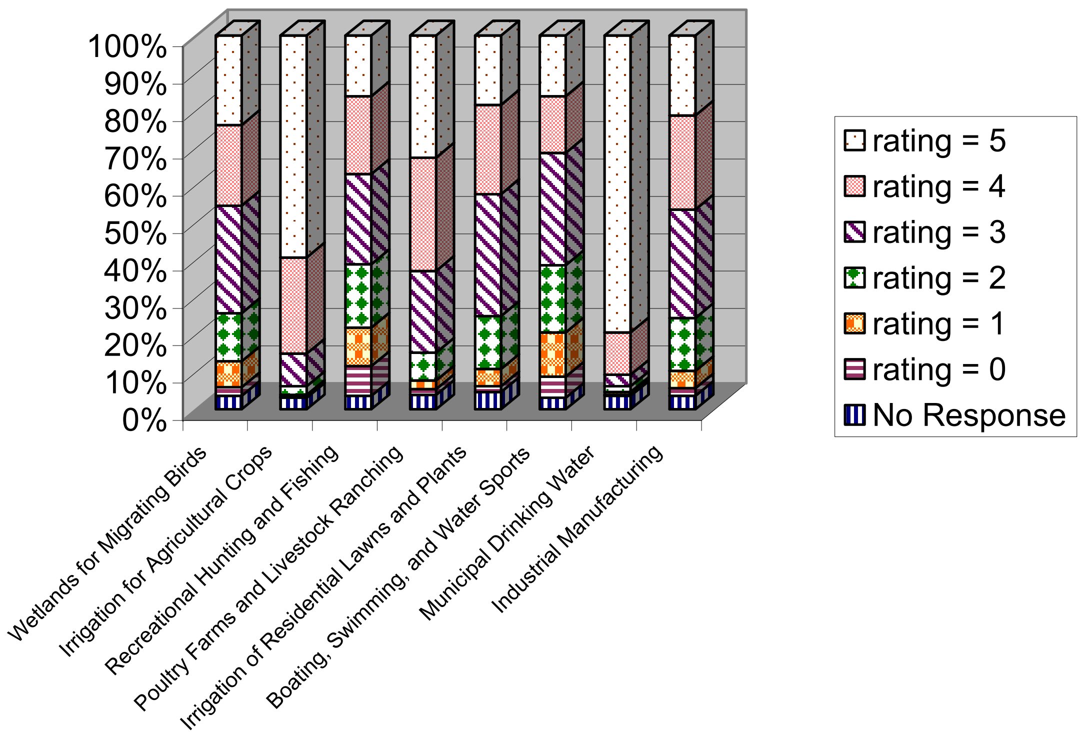

Table 4.3.6. Respondents' Ratings of the Importance of Uses of Water

	Wetlands for Migrating Birds	Irrigation for Agricultural Crops	Recreational Hunting and Fishing	Poultry Farms and Livestock Ranching	Irrigation of Residential Lawns and Plants	Boating, Swimming, and Water Sports	Municipal Drinking Water	Industrial Manufacturing
No Response	14	12	14	15	18	12	14	14
rating = 0	9	1	31	6	6	22	1	8
rating = 1	27	2	40	9	18	46	3	18
rating = 2	50	9	66	29	55	70	6	55
rating = 3	112	34	94	85	127	117	12	113
rating = 4	84	100	81	118	93	59	44	98
rating = 5	93	231	63	127	72	63	309	83

A set of questions about the quality of the household's tap water follows the section on uses of water. On the ratings scale used for these questions (Figure 4.3.3), a value of 0 indicates poor quality while a value of 5 indicates excellent quality. When asked to rate the taste of their tap water, 30% gave it a 3. Thirty-one percent gave it a 0, 1, or 2, and the remaining gave it a 4 or 5 (Figure 4.3.4, Table 4.3.6). When asked to rate the smell of their tap water, 25% of respondents gave it a 0, 1, or 2, and 53% gave it a 3 or a 4

(Figure 4.3.4, Table 1.6). The color of households' tap water seems to be the best of the three attributes mentioned thus far. Only 16% gave it a value of 0, 1, or 2. Thirty-three percent rated it as a 4 (Figure 4.3.4, Table 4.3.6). Finally, the survey asks households to rate how well their tap water cleans their clothing and dishes. The results for both types of cleaning are similar (Figure 4.3.4, Table 4.3.6).

Figure 4.3.3.
Scale for Rating Household Water Quality

Poor			Fair		Excellent
0	1	2	3	4	5

Figure 4.3.4.
Tap Water Quality

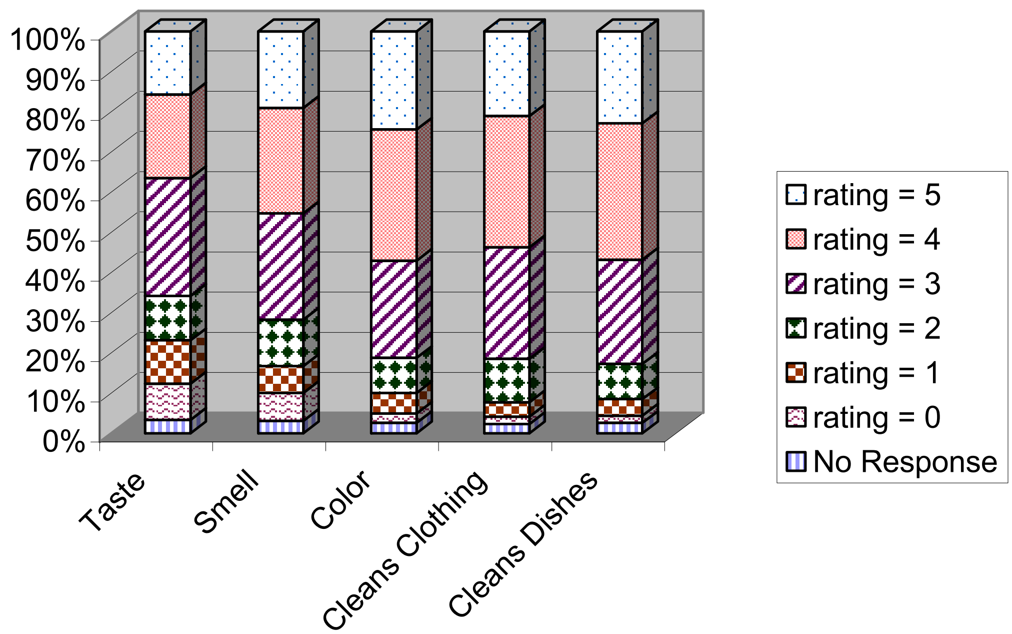

Table 4.3.6.
Tap Water Quality

	Taste	Smell	Color	Cleans Clothing	Cleans Dishes
No Response	13	12	10	9	10
rating = 0	35	27	9	7	7
rating = 1	42	26	20	14	16
rating = 2	43	45	34	42	34
rating = 3	114	103	94	108	101
rating = 4	81	102	127	127	132
rating = 5	61	74	95	82	89

4.3.2 Section 2: Your Uses of Water

A more objective section on how households actually use water both in their home and in the outdoors follows the initial subjective section. The survey contains these questions to collect information on how San Joaquin Valley residents use water and also to encourage respondents to consider how they use water.

This section begins by asking households if they have a yard, to which 91% responded in the affirmative (Table 4.3.7). Those households that did not have a yard were instructed to skip those questions that consequently did not pertain to them.

Table 4.3.7.
Do you have a yard (private or shared)?

	Number	Percent
Yes	355	91%
No	23	5.9%
No Response	11	2.8%
Total	389	100%

To identify households with larger yards and potentially different water needs and attitudes, the survey asks if the respondent's yard is larger than 1 acre. Only 7% of respondents answered yes to this question (Figure 4.3.5, Table 4.3.8). The next question asks whether the household has sprinklers or an irrigation system in their yard. Four fifths of respondents indicated that they do have sprinklers or an irrigation system (Figure 4.3.5, Table 4.3.8). Given the rural nature of some of the areas included in the sample, the survey asks whether or not the household's residence has a well. About one-fifth of respondents indicated that they do have a well (Figure 4.3.5, Table 4.3.8).

Figure 4.3.5.
Does your household have the following?

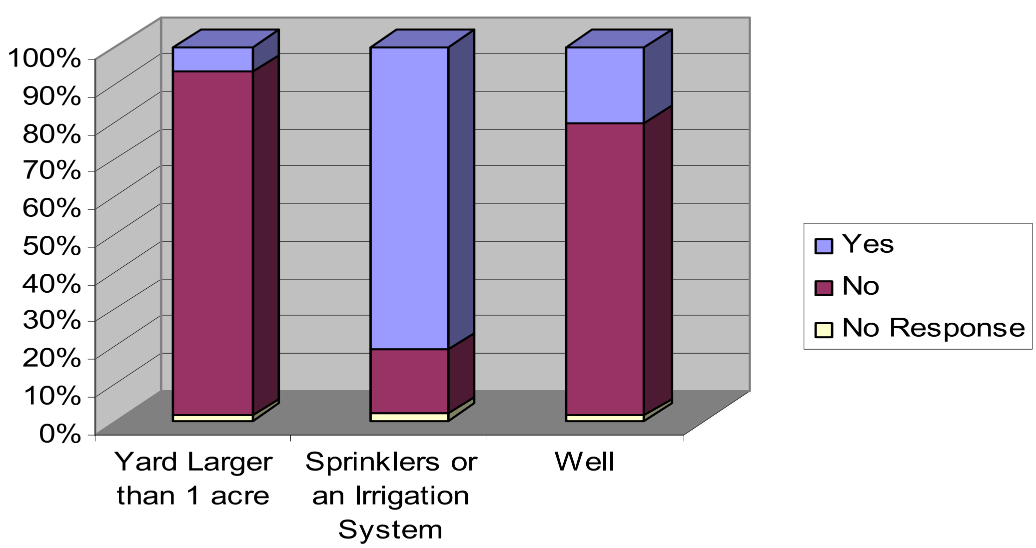

Table 4.3.8.
Does your household have the following?

	Yard Larger than 1 acre	Sprinklers or an Irrigation System	Well
Yes	24	287	72
No	326	61	278
No Response	5	7	5
Total	355	355	355

Since various uses of yards consume different amounts of water, the survey asks respondents to indicate which of a list of eight items their yards contain. Ninety-four percent of households' yards contain grass. Shade trees were the next most common, with 76% of households indicating their presence. A little less than half of respondents had domestic pets and fruit or nut trees in their yards (Table 4.3.9).

Table 4.3.9.
Does your yard contain any of the following? (Please check all that apply)

	Number	Percent
Grass	332	94%
Shade Trees	271	76%
Domestic Pets	176	50%
Fruit or Nut Trees	159	45%
Vegetable Garden	90	25%
Pool	84	24%
Hot Tub	35	9.9%
Chickens	7	2.0%

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To learn about households' drinking water habits, the survey asks about water softener use and purified water purchases. About fifteen percent of households use water softeners (Figure 2.2, Table 2.4), and about half purchase purified water or use a water delivery service (Figure 2.2, Table 2.4).

Figure 4.3.6.
Household Water Habits

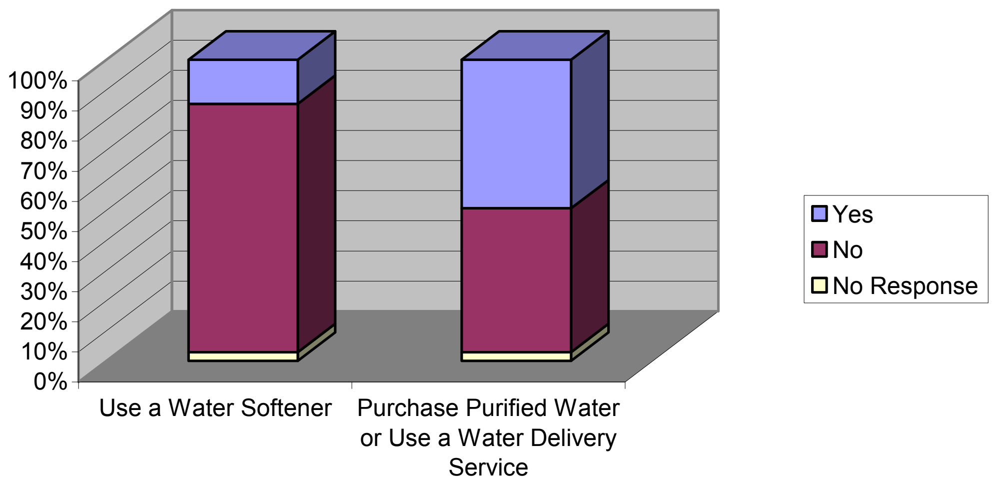


Table 4.3.8
Household Water Habits

	Use a Water Softener	Purchase Purified Water or Use a Water Delivery Service
Yes	57	192
No	321	186
No Response	11	11
Total	389	389

Initial Draft

Even though half of households purchased water, 85% still indicated that they use tap water (Figure 4.3.6). The majority of households (69%) who use tap water, use unfiltered tap water for cooking, and 52% of tap water using households use filtered tap water for drinking (Figure 4.3.8, Table 4.3.9).

Figure 4.3.7
Does your household use tap water for cooking or drinking?

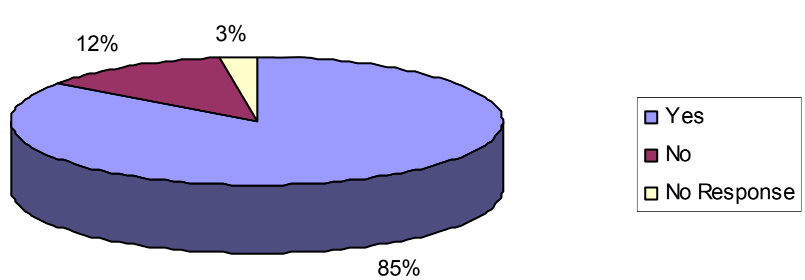
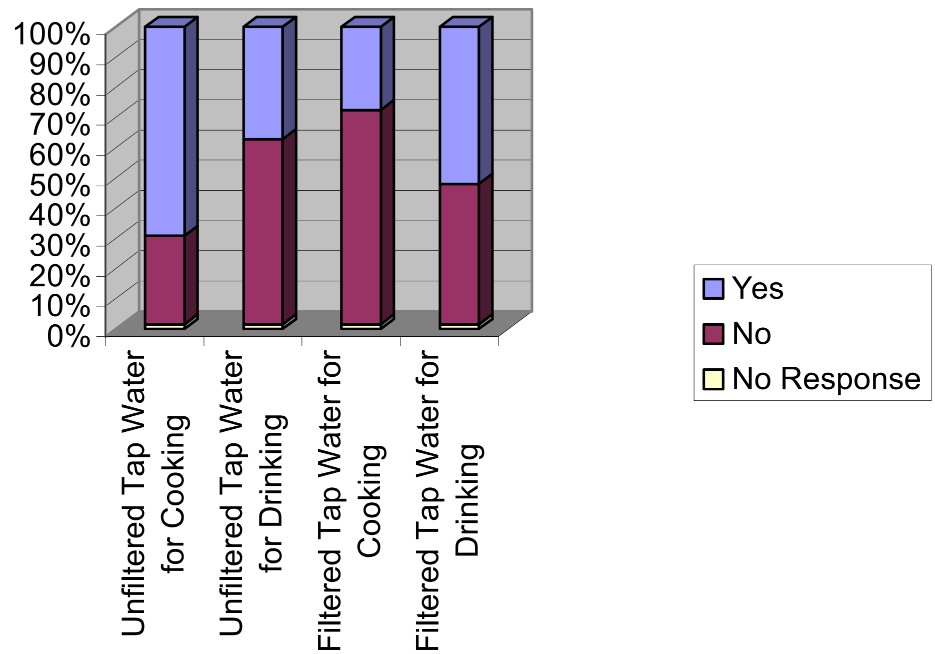


Figure 4.3.9 Uses of Tap Water



Initial Draft

Table 4.3.9. If your household uses tap water, please tell us how by checking all that apply.

The survey then follows up with a question on the types of filters used. Forty percent said they do not use a filter, and among filters used, refrigerator mounted filters are the most common, with 35% of respondents indicating that they use them (Table 4.3.10).

Table 4.3.10
Does your household use any of the water filters listed below? (Please check all that apply)

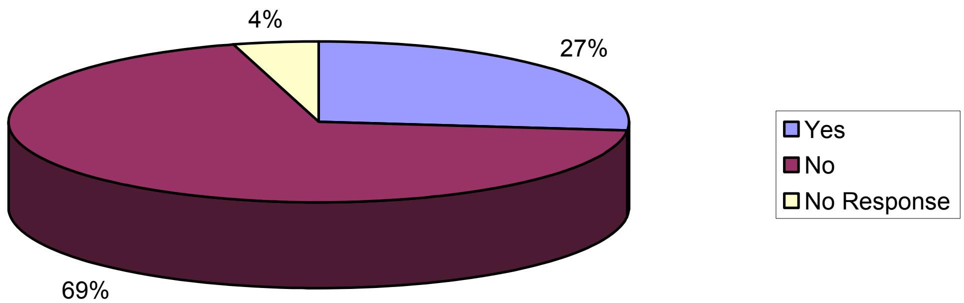
	Number	Percent
A Refrigerator Mounted Filter	134	34%
A Sink Mounted Filter	69	18%
A Pitcher Filter	37	9.5%
A Reverse Osmosis Water System	32	8.2%
No Filter	155	40%
No Response	13	3.3%
Total	389	100%

After asking respondents about their uses of water in the home, the survey asks about

	Unfiltered Tap Water for Cooking	Unfiltered Tap Water for Drinking	Filtered Tap Water for Cooking	Filtered Tap Water for Drinking
Yes	229	123	91	172
No	97	203	235	154
No Response	5	5	5	5
Total	331	331	331	331

outdoor recreation involving water. Twenty-seven percent indicated that during 2006, they spent some time hunting, boating, or viewing wildlife on the San Joaquin Valley floor (Figure 4.3.10).

Figure 4.3.10.
During 2006, did you spend any time hunting, boating, or viewing wildlife on the San Joaquin Valley floor?



Initial Draft

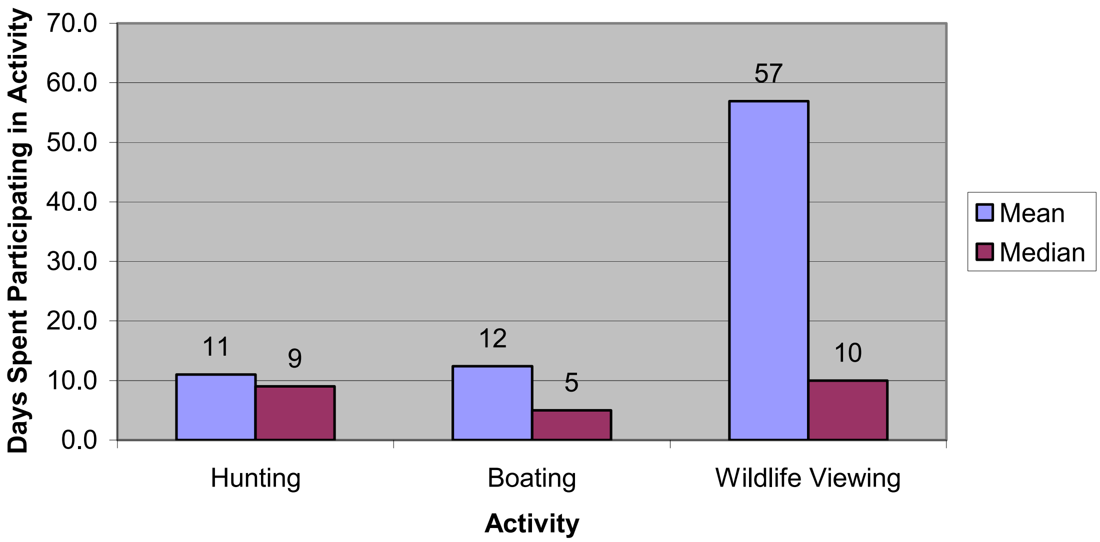
Wildlife viewing is the most common form of recreation among the three activities discussed. Seventeen percent of respondents participated in wildlife viewing in 2006. Twelve percent boated, and 8% hunted in the Valley in 2006 (Table 4.3.11).

Table 4.3.11.
Percentage of Respondents Who Indicated They Participated in the Following Activities in 2006 in the San Joaquin Valley

	Number	Percent
Hunting	30	7.7%
Boating	47	12%
Wildlife Viewing	67	17%

Among those who participated in hunting, boating, and wildlife viewing, the average number of days spent doing each of these activities was 11, 12, and 57 respectively (Figure 4.3.11). Wildlife viewing was divided into 2 categories: viewing when viewing is the main purpose of the outing and viewing when viewing is incidental to other activities such as driving or biking along Valley roads. The majority of wildlife viewing occurs incidentally, with an average of 43 days spent viewing wildlife on outings for a different purpose.

Figure 4.3.11.
How many days did you participate in the following activities on the San Joaquin Valley floor in 2006?



To see how far people are willing to travel for each of these activities, the survey asks how many miles the household traveled to where they hunted, boated, or viewed wildlife most often. Both hunters and boaters traveled an average of 31 miles, while wildlife viewers traveled an average of 33.8 miles (Table 4.3.12).

Table 4.3.12.
How many miles did you travel (one-way) to where you participated in the following activities most often?

	Mean	Median
Hunting	31	30
Boating	31	28
Wildlife Viewing	34	20

Of those who indicated that they hunted in 2006, the survey asks how many of each type of animal the hunter took in 2006. Most respondents just checked the type of animal instead of indicating how many. Hunters most commonly hunted doves, with 43% of hunters indicating that they took doves in 2006. Thirty percent of hunters hunted pheasants and deer (Table 4.3.14).

Table 4.3.14.
Number and Percent of Hunters Who Took Each of the Following Types of Animals in 2006

	Number	Percent
Doves	13	43%
Deer	9	30%
Pheasants	9	30%
Squirrels	5	17%
Ducks	5	17%
Turkeys	2	6.7%
Geese	2	6.7%
Other	5	17%
Quail	2	6.7%
Boar	1	3.3%
Coyote	1	3.3%
Fish	1	3.3%
No Response	3	10.0%

4.3.3 Section 3: The Salinity Management Plan

Initial Draft

The third section provides information about the causes and effects of water salinity in the San Joaquin Valley. It then discusses the steps a salinity management plan would take to stop the increase of salinity in the Valley, which would result in more land in agricultural production and wetlands, and fewer premature deaths due to air pollution, compared with having no salinity management plan in place. Finally, it informs the respondents that a surcharge on monthly water and sewer bills of businesses and households would collect funds to cover the costs of the plan.

Two response formats were used for this question, with households being assigned randomly to one or the other. In one format (the “Single Bound” surcharge), after providing information about the plan, respondents were asked if they would pay a surcharge of a specified amount. In the other (Double Bound) format, a follow-up surcharge question was asked after the first one. If they responded “yes” to the initial surcharge amount, respondents receiving this version of the question were asked if they would pay a higher amount. If they responded “no” initially, they were asked if they would be willing to pay a given lower amount. The mean values of the initial, higher, and lower surcharge amounts are shown in Table 4.3.15 below.

Table 4.3.15.
Mean Values of the Initial, High, and Low Monthly Surcharges

	Mean
Single Bound	
Surcharge	$16.34
Double Bound	
Initial Surcharge	$14.58
High Surcharge	$32.43
Low Surcharge	$8.36

Among those respondents who received surveys with a single bounded question, 73% answered that they would not pay the amount given, while 6% gave no response to the question (Table 4.3.16).

Table 4.3.16.
Patterns of Responses to the Surcharge Question for Those Respondents Receiving Single Bounded Questions

	Number	Percent
Yes	29	20%
No	105	73%
No Response	9	6.3%
Total	143	100%

Initial Draft

Among those respondents receiving initial and follow-up surcharge questions, 18% answered yes to the initial surcharge question. Of those who answered yes, 23% then answered yes to the higher surcharge amount. Sixty-one percent answered no to the initial surcharge question, and within this group, 13% answered yes to the lower surcharge amount. Twenty-one percent did not respond to the initial surcharge question (Table 4.3.17).

Table 4.3.17.
Patterns of Responses to the Initial and Follow-Up Surcharge Questions for Those Respondents Receiving Double Bounded Questions

	Follow Up Surcharge					
	Higher		Lower			
Initial Surcharge	Yes	No	Yes	No	No Response	Total
Yes	10	30			4	44
No			33	110	8	151
No Response	2	7	13	5	24	150
Total	12	37	46	115	36	246

To those who answered "no" to the initial and lower surcharge amount (or just the initial surcharge for those receiving the Single Bound format), the survey asks if the respondent would be willing to pay any amount to fund the salinity management plan.

Among those respondents receiving the single bounded question, 35% were willing to pay some amount, with the mean amount being $5.73. Among those respondents receiving the double bounded questions, 24% were willing to pay some amount, with the mean amount being $3.67 (Table 4.3.18).

Table 4.3.18.
Would you pay any amount to fund the Salinity Management Plan?

	Single Bounded		Double Bounded	
	Number	Percent	Number	Percent
No (Not willing to pay anything)	61	59%	78	71%
Yes (Willing to pay something)	36	34%	26	24%
mean amount	$5.73		$3.67	
median amount	$5.00		$5.00	
No Response	8	7.6%	6	5.5%
Total	105	100%	110	100%

Since different versions of the survey contain different bid levels, the responses to these different levels can be used to determine how the proportion of the sample saying "yes" (they would pay for the Salinity Management Program) varies with the surcharge they would have to pay. Tables 4.3.19 and 4.3.20, below, show the numbers of "yes" and "no" responses received for each surcharge levels respondents faced. A graphical depiction of the information in these tables can be found in Figures 4.3.12 and 4.3.13.

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Table 4.3.19.
Responses to Different Surcharge Levels by Respondents Receiving Double Bounded Questions

	Yes	No	No Response
$3	12	11	5
$5	13	17	11
$6	5	7	3
$7	4	6	4
$8	14	25	9
$9	2	12	1
$10	11	20	7
$12	17	43	17
$14	11	46	8
$16	3	12	3
$18	3	15	2
$20	3	15	4
$22	4	29	8
$24	0	5	5
$25	3	15	3
$30	0	5	2
$37	1	6	0
$42	0	6	1
$48	1	2	1
$54	0	11	3

Table 4.3.20.
Responses to Different Surcharge Levels by Respondents Receiving Single Bounded Questions

	Yes	No	No Response
$10	4	13	4
$12	6	13	2
$16	4	17	2
$18	7	20	0
$20	7	43	1

Figure 4.3.12.
Proportion of Respondents Saying They Would Pay the Surcharge, by Surcharge Level (Double Bound Version)

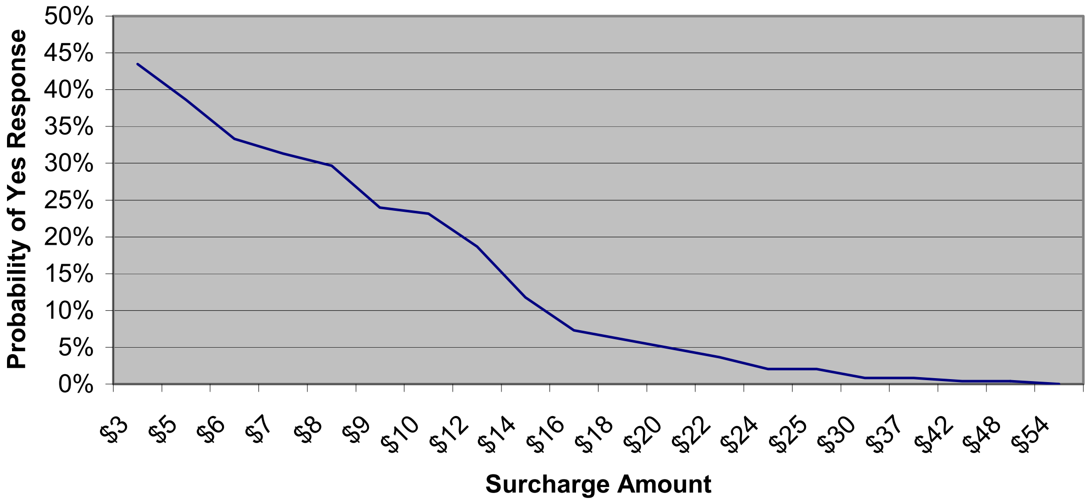
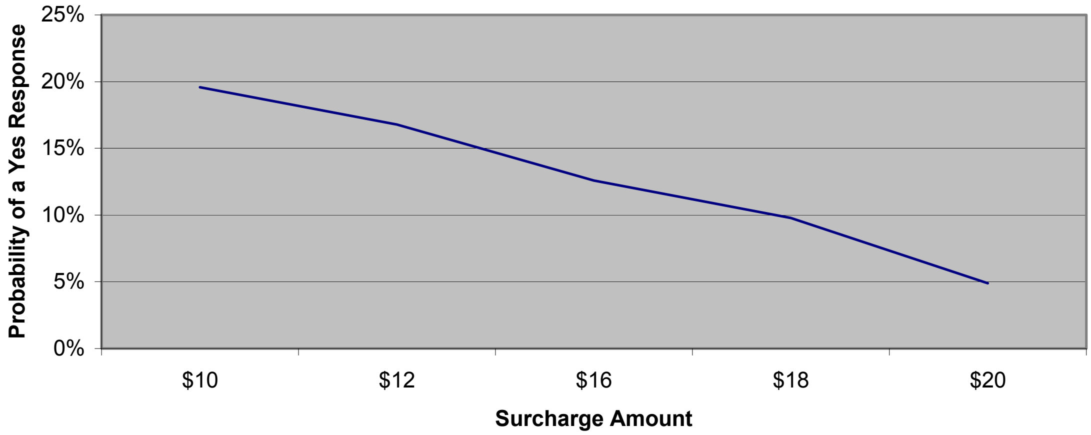


Figure 4.3.13.
Proportion of Respondents Saying They Would Pay the Surcharge, by Surcharge Level (Single Bound Version)



If the respondent indicated that they are not willing to pay any amount to fund the salinity management plan, the survey asks why they are not willing to pay anything. Twenty-six percent of respondents are not willing to pay any amount because they do not believe they receive any benefit from the plan (Table 4.3.21), while 19% indicate that it is more important to spend their money on other things, and 16% say the government shouldn't be involved in reducing salinity. Forty percent of respondents chose "other" and wrote in reasons. Almost half of these written-in reasons made reference to low incomes or high expenses or qualms about the government. If these responses are added to those who believe "it's more important to spend my money on other things" or that "the government shouldn't be involved in reducing salinity," the percentages for these categories increase to 32.5% and 21.7%, respectively.

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Table 4.3.21.
Why were you not willing to pay any amount to fund the Salinity Management Plan?

	Number	Percent
I don't feel I get any benefit from this plan.	40	26%
It's more important to spend my money on other things.	30	19%
The government shouldn't be involved in reducing salinity.	26	17%
Other	63	40%
No Response	16	10%

4.3.4 Section 4: Would Your Activities Change?

After discussing the possible steps needed to reduce salinity, the survey discusses what will happen to wildlife if no action is taken. It then asks how households' outdoor activities would change if the populations of animals hunted and viewed decreased. Four formats were used. Each format contained a scenario with either a 20% or 30% decrease in hunting success rates and a scenario with either a 35% or 50% decrease in number of birds and wildlife viewed (Table 4.3.22).

Table 4.3.22
Levels of Hunting Success Rate and Birds and Wildlife Viewing Decreases

	Success Rate Decrease	Viewed Wildlife Decrease
Format 1	20%	35%
Format 2	30%	35%
Format 3	20%	50%
Format 4	30%	50%

Nineteen respondents who indicated that they hunt or view wildlife in the Valley received surveys with formats 1 and 3. Fifty-eight who hunted or viewed wildlife received surveys containing formats 2 and 4. Of those facing a 20% decrease in success rates, 58% said the number of days they hunted would not have changed. One person responded that they would hunt more, and no one said they would hunt less. Of those facing a 30% decrease in success rates, 53% said the number of days they hunted would not change, while 12% said they would hunt less, and 5% said they would hunt more (Table 4.3.23).

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Table 4.3.23
If success rates for the species you hunted in 2006 dropped by the percent shown below, would you change the number of days you spent hunting on the San Joaquin Valley floor?

	Number	Percent
20%		
More	1	5.3%
Less	0	0.0%
No Change	11	58%
No Response	7	37%
30%		
More	3	4.9%
Less	7	12%
No Change	32	53%
No Response	19	31%

The survey asked a similar question about wildlife viewing. Among those who faced a 35% decrease in numbers, 78% said they would not change the number of days they viewed wildlife, while 9% said they would spend more days viewing, and 9% said they would spent fewer days viewing. Of those respondents facing a 50% decrease, 69% said they would not change the number of days they viewed, 9% said they would view more, and 11% said they would view less (Table 4.3.24).

Table 4.3.24.

If the number of birds and wildlife you viewed on outings in 2006 dropped by the percent shown below, would you change the number of days you spent viewing wildlife on the San Joaquin Valley floor?

	Number	Percent
35%		
More	4	8.9%
Less	4	8.9%
No Change	35	78%
No Response	2	4.4%
50%		
More	3	8.6%
Less	4	11%
No Change	24	69%
No Response	4	11%

4.3.5 Section 5: What Policy Choices Would You Make?

This section of the survey sought to determine which effects of salinity Valley residents feel most strongly about. In this section, respondents were presented with a series of comparisons between two different salinity management plans, as well as the option of doing nothing to manage salinity, and the expected consequences of each were described. The expected consequences were different levels of land in agricultural production, land in seasonal and permanent wetlands, and air quality effects measured in deaths per year. Each salinity management plan also had a monthly cost to the household, while doing nothing cost nothing. Depending on the version of the survey received, households were presented with either 3 or 5 of these comparisons between two alternative salinity plans and doing nothing. The respondent was then asked to choose their most preferred option in each comparison.

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In total, the surveys contained 9 different comparisons between salinity management plans (though no one person received more than 5). Table 4.3.25 below shows the attribute levels for each plan and the number of people preferring that plan. The percent preferring that plan is the portion that chose a given plan among those who were asked to make the comparison.

Table 4.3.25.
Attribute Levels for the Salinity Management Plan Comparisons

Level	Land in Agricultural Production	Land in Seasonal and Permanent Wetlands	Air Quality Effect	Price
Lowest	1,900,000 acres[a]	24,000 acres	-	$0/month
Low	2,100,000 acres	57,000 acres	8,900 deaths/year	$9/month
Medium	2,300,000 acres	88,000 acres	9,500 deaths/year	$15/month
High	2,600,000 acres	112,000 acres	10,100 deaths/year	$28/month
Highest	-	-	10,900 deaths/year	-

[a] The underlined levels are the best estimates of what would happen with no Salinity Management Pl

Table 4.3.26.

Results of the Comparisons between Salinity Management Plans

Comparison	Plan	Land in Agricultural Production	Land in Seasonal and Permanent Wetlands	Air Quality Effect	Price	Number Preferring	Percent Preferring
1	A	High	High	High	Low	79	39%
	B	Medium	Low	Medium	High	19	9.5%
	No Plan	Lowest	Lowest	Highest	Lowest	55	27%
	No Response					48	24%
2	A	High	Low	Low	Low	90	39%
	B	Low	High	Medium	Medium	23	10%
	No Plan	Lowest	Lowest	Highest	Lowest	67	29%
	No Response					50	22%
3	A	High	Medium	High	Medium	73	33%
	B	Low	High	Medium	High	24	11%
	No Plan	Lowest	Lowest	Highest	Lowest	76	34%
	No Response					50	22%
4	A	Low	Low	Low	High	31	14%
	B	High	Medium	High	Low	71	32%
	No Plan	Lowest	Lowest	Highest	Lowest	69	31%
	No Response					49	22%
5	A	Low	Medium	High	Medium	19	11%
	B	Medium	Low	Medium	Low	69	42%
	No Plan	Lowest	Lowest	Highest	Lowest	46	28%
	No Response					32	19%
6	A	Low	Medium	Medium	High	8	4.8%
	B	Medium	High	Low	Low	81	49%
	No Plan	Lowest	Lowest	Highest	Lowest	39	24%
	No Response					38	23%
7	A	Medium	Low	Low	Medium	67	40%
	B	Low	High	High	High	7	4.1%
	No Plan	Lowest	Lowest	Highest	Lowest	52	31%
	No Response					43	25%
8	A	Medium	Medium	Low	Low	44	39%
	B	High	High	High	Medium	11	9.8%
	No Plan	Lowest	Lowest	Highest	Lowest	29	26%
	No Response					28	25%
9	A	Medium	Medium	Medium	High	11	6.7%
	B	High	Low	Low	Medium	63	38%
	No Plan	Lowest	Lowest	Highest	Lowest	52	32%
	No Response					38	23%

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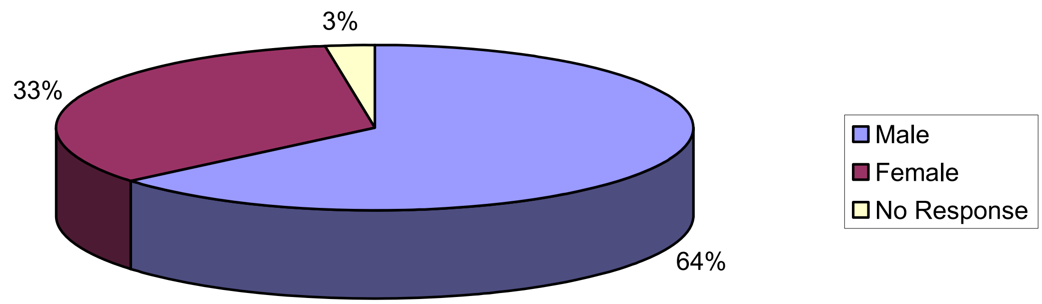
4.3.6 Section 6: About You

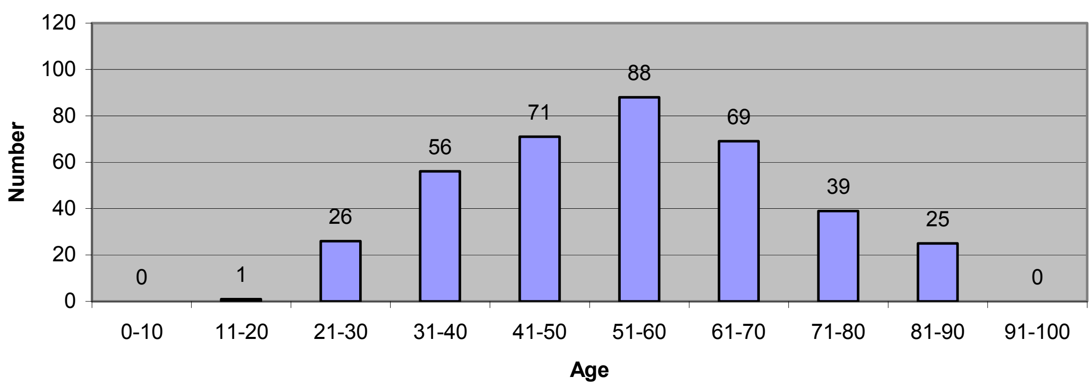
The final section contains socioeconomic questions whose purpose is to understand in what ways the survey respondents are similar to and differ from the populations of the San Joaquin Valley and California as a whole. This section begins by asking respondents their gender. Sixty-four percent are male, 33% are female, and 3% did not respond to this question (Figure 4.3.14).

Figure 4.3.14.
What is your gender?



Next, respondents are asked their age. Twenty-two percent were aged fifty-one to sixty years. Ages ranged from 18 to 89 years (Figure 4.3.15). The average age was 54.6 and the median age was 54.

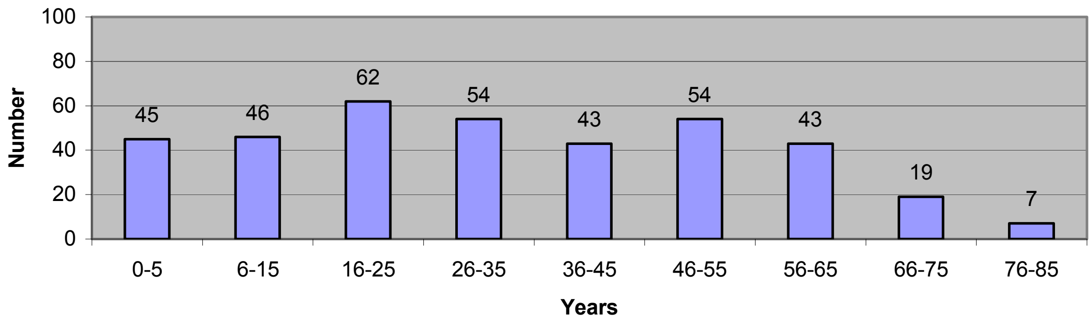
Figure 4.3.15.
What is your age?



Next, respondents are asked how long they have lived in the San Joaquin Valley. Responses ranged from 0 to 85 years with a mean length of 33.7 and median length of

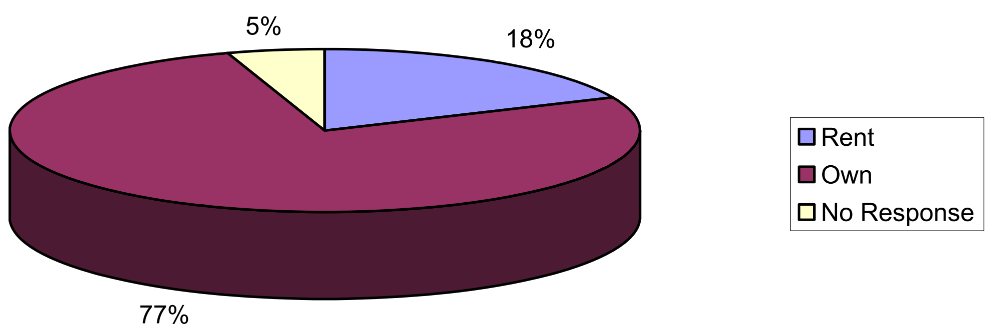
33. While the age distribution is clearly unimodal and relatively symmetric, the length of San Joaquin residency distribution is bimodal and asymmetric (Figure 4.3.16).

Figure 4.3.16.
How long have you lived in the San Joaquin Valley?



Following the question on residency, the survey asks about tenancy. The majority of households, 77%, own their current residence, while 18% rent and 5% didn't respond to this question (Figure 4.3.17).

Figure 4.3.17
Do you rent or own your current residence?



The survey then asks what languages are spoken at home. Eighty-nine percent speak English at home, while 19% speak Spanish and 6% speak a language other than English or Spanish (Table 4.3.27).

Table 4.3.27.
What languages are spoken in your household? (Please check all that apply)

	Number	Percent
English	347	89%
Spanish	73	19%
Other	22	5.7%
Portuguese	5	1.3%
Hmong	3	0.8%
Chinese	2	0.5%
Pilipino	2	0.5%
Tagalog	2	0.5%
Armenian	1	0.3%
Cherokee	1	0.3%
Italian	1	0.3%
Japanese	1	0.3%
Laos	1	0.3%
Norwegian	1	0.3%
Vietnamese	1	0.3%
No Response	12	3.1%

Also in this section, the survey asks about education completed. Thirty-five percent of respondents have at least a college degree. 4% of respondents chose not to answer this question (Table 4.3.28).

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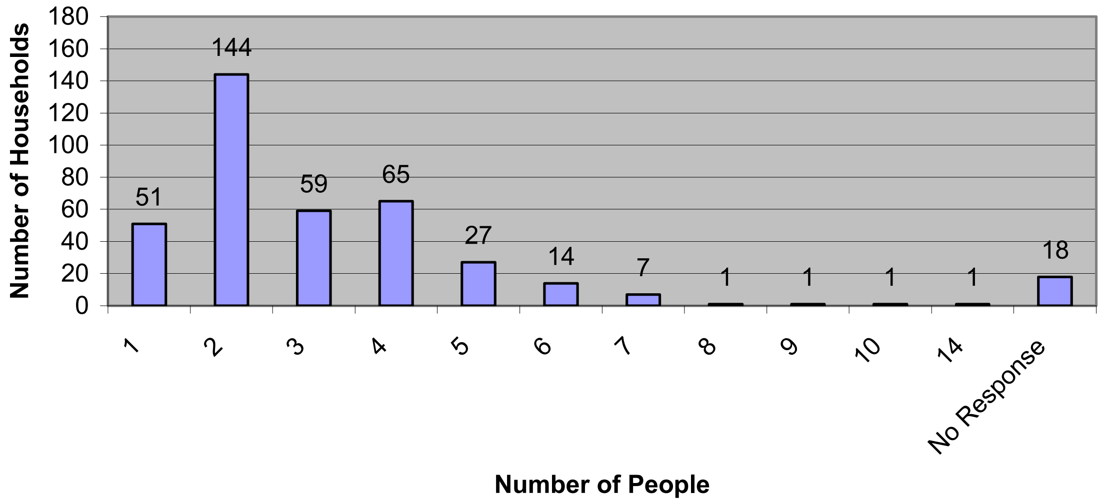
Table 4.3.28.
How many years of schooling have you completed? (Please check the highest level completed)

	Number	Percent
Elementary (K-8)	28	7.2%
High School	91	23%
Some College	116	30%
College	81	21%
Post-College	56	14%
No Response	16	4.1%
Total	389	100%

To learn about household size and composition, the surveys asks respondents how many people live in their households and then how many people fall into various age categories. About half of all households contain 1 or 2 members. 32% contain 3 or 4 members, and 7 percent contain 5 or more members (Figure 4.3.18).

Figure 4.3.18
Including yourself, how many people currently live in your household?



Sixty-three percent of households contain at least 1 member who is between the ages of 19 and 59. 30% contain children between the ages of 6 and 18, and 18% contain children under 6 years of age. There was a relatively high non-response rate of 11% for this question.

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Table 4.3.29
Age Distribution within Households.

	Number of households	Percent of households	Mean number (among households with members in this category)	median number
Children under 6	68	18%	1.4	1.0
Children Ages 6-18	117	30%	1.8	2.0
Ages 19-59	243	63%	2.0	2.0
Over Age 60	142	37%	1.5	2.0
No Response	43	11%		

Since health problems are among the effects of salinity, the survey asks about common health issues. 46% of respondents report suffering from allergies and 39% take blood pressure medication. 19% have asthma and use an inhaler. Seventeen percent of households reported not suffering from many of the mentioned health problems (Table 4.3.30).

Table 4.3.30.
Below are some common health problems. Please check all that apply to your household.

	Number	Percent
Has allergies	176	45%
Takes blood pressure medication	151	39%
Uses an inhaler	74	19%
Has asthma	74	19%
Smokes tobacco	64	17%
Has heart disease	63	16%
Has hypertension	45	12%
Suffers from chronic bronchitis	14	3.6%
Has none of the above health	67	17%
No Response	21	5.4%

Following this question, the survey asks about the number of people in the household working for pay. Sixty percent of households had 1 or 2 people working, while 20% had no one working (Table 4.3.31).

Table 4.3.31.
How many people in your household work for pay?

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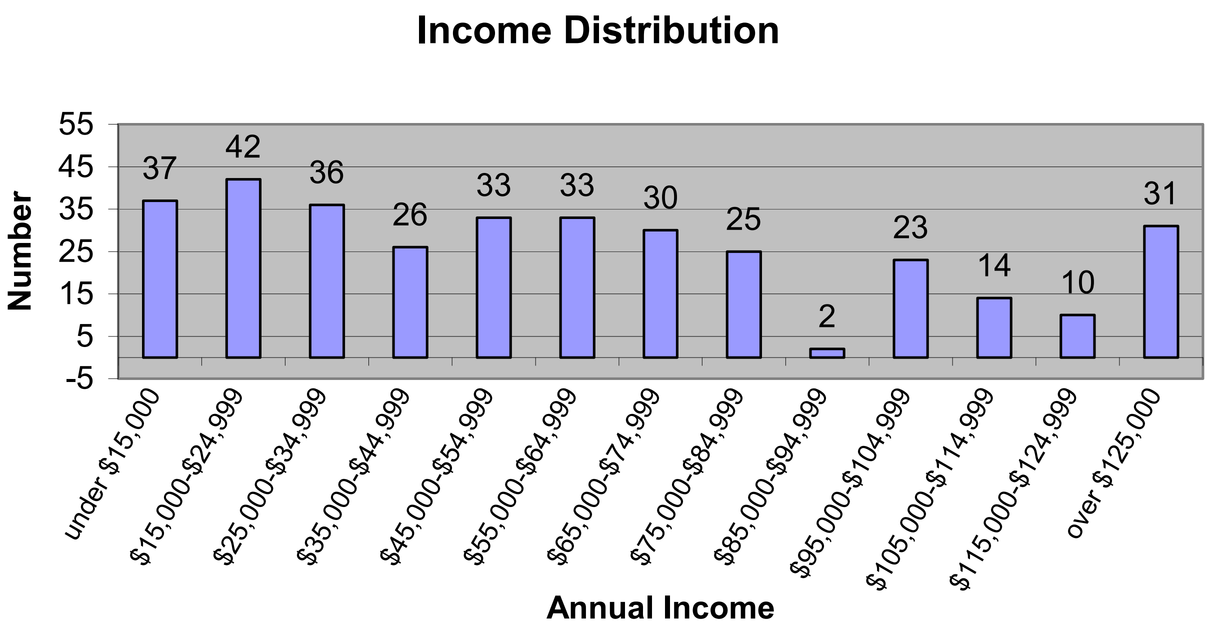
	Number	Percent
0	78	20%
1	125	32%
2	109	28%
3	26	6.7%
4	7	1.8%
5	2	0.5%
No Response	42	11%
Total	389	100%

Finally, the survey asks what the household's annual income was before taxes in 2006. Twelve percent of households chose not to answer this question. Twenty percent of respondents made less than $25,000, while another 20% made $95,000 or more (Figure 4.3.19).

Figure 4.3.19.
What was your total annual household income last year (before taxes)?



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Onehundred forty of the surveys received had a box that respondents could check if they wished to receive the survey results, while 245 did not contain the box. Instead, respondents receiving this latter group of surveys were instructed in the cover letter to write "Survey Results Requested" on their survey if they wished to receive results. Fifty-three percent of respondents receiving a survey with a box to check requested results while only 7% of those without a box requested results (Table 4.3.31).

Table 4.3.31.
Results Requested by Survey Type.

	Number	Percent
Box Available to Check	75	53%
No Box Available	16	6.5%
Total	91	23%

4.4 Household Willingness to Pay for Salinity Management: Contingent Valuation and Choice Experiments Analyses

This section first develops the models used for analyzing the responses received to the contingent valuation and choice experiments. Then the results of empirical estimation are presented, along with the implied willingness to pay for a salinity management program.

4.4.1 Descriptive Statistics for the Willingness to Pay Analysis

The principal variables used in the contingent valuation analysis are summarized in Tables 4.4.1 (all observations) and 4.4.2 (observations used in the empirical analysis). Table 4.4.1 provides a broader look at the sample of people whose information is used in the analysis, and identifies the item nonresponse for each variable (Missing column). The variable definitions are:

Rural, North, Central refer to the region of the San Joaquin Valley the respondent lives in and give the proportion residing in each;
Hispanic, English, OthLang refer to the main language spoken at home, and give proportions of each;
Hhsize, Hhu6, Hh618, Hh1959, Hho59 are total household size and the number of members under 6 years of age, between 6 and 18, between 19 and 59, and over 59, respectively;
Female is a dummy variable with the value 1 if respondent is female, 0 otherwise;
Age is respondent age, in years;
SJVRes is the number of years respondent has been a San Joaquin Valley resident;
Rent is a dummy variable taking the value 1 if respondent rents their home, 0 otherwise;
Asthma, Smokes, Blood Pressure, Hypertension, Allergy, Bronchitis, Inhaler are dummy variables taking the value 1 if respondent said one or more people in the household suffered from these symptoms;
Workers is the number of wage-earners in the household;
Income is household income before taxes;
Dblbound is a dummy taking the value 1 if the double-bound format was used, 0 otherwise;
Elementary, High school, Some college, College, Post-college refer to the highest level of education completed by the respondent, and are dummy variables taking the value 1 if that level is the highest completed, 0 otherwise;
Ed45 is a dummy variable taking the value 1 if respondent has completed college or more;
Edu is the number of years of schooling, assigning 10 for elementary, 12 for high school, 14 for some college, 16 for college, 18 for post-college;
Health is the number of health symptoms reported for the household;
Health2 is a dummy variable taking the value 1 if the household reported at least one symptom, 0 otherwise;
Ncent is a dummy variable taking the value 1 if respondent lives in northern or central San Joaquin Valley, 0 otherwise;

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Table 4.4.1. Descriptive Statistics for the Willingness to Pay Sample

Variable	Mean	Standard Deviation	Minimum	Maximum	Valid	Missing
Rural	0.3657	0.4823	0.0000	1.0000	391	0
North	0.3606	0.4808	0.0000	1.0000	391	0
Central	0.3325	0.4717	0.0000	1.0000	391	0
South	0.3069	0.4618	0.0000	1.0000	391	0
Hispanic	0.1893	0.3922	0.0000	1.0000	391	0
English	0.9208	0.2703	0.0000	1.0000	379	12
Spanish	0.1926	0.3949	0.0000	1.0000	379	12
OthLang	0.0580	0.2341	0.0000	1.0000	379	12
Hhsize	2.9223	1.6303	1.0000	14.000	373	18
Hhu6	0.2686	0.6121	0.0000	4.0000	350	41
Hh618	0.6257	1.0571	0.0000	6.0000	350	41
Hh1959	1.3966	1.1801	0.0000	8.0000	348	43
Hho59	0.6254	0.8176	0.0000	3.0000	347	44
Female	0.3412	0.4747	0.0000	1.0000	381	10
Age	54.6592	15.8936	18.000	89.000	377	14
SJVRes	33.6373	21.3783	0.0000	85.000	375	16
Rent	0.2016	0.4017	0.0000	1.0000	372	19
Asthma	0.2000	0.4005	0.0000	1.0000	370	21
Smokes	0.1730	0.3787	0.0000	1.0000	370	21
Blood pressure	0.4108	0.4926	0.0000	1.0000	370	21
Hypertension	0.1216	0.3273	0.0000	1.0000	370	21
Allergy	0.4784	0.5002	0.0000	1.0000	370	21
Heart disease	0.1703	0.3764	0.0000	1.0000	370	21
Bronchitis	0.0378	0.1911	0.0000	1.0000	370	21
Inhaler	0.2000	0.4005	0.0000	1.0000	370	21
Workers	1.3238	1.0035	0.0000	5.0000	349	42
Income	61795.	43447.	7500.0	160000.	344	47
Dblbound	0.6292	0.4836	0.0000	1.0000	391	0
Elementary	0.0716	0.2582	0.0000	1.0000	391	0
High school	0.2353	0.4247	0.0000	1.0000	391	0
Some college	0.2992	0.4585	0.0000	1.0000	391	0
College	0.2072	0.4058	0.0000	1.0000	391	0
Post-college	0.1432	0.3507	0.0000	1.0000	391	0
Ed45	0.3504	0.4777	0.0000	1.0000	391	0
Edu	14.240	2.3239	10.000	18.000	374	17
Health	1.6957	1.3912	0.0000	6.0000	391	0
Health2	0.7724	0.4198	0.0000	1.0000	391	0
Ncent	0.6931	0.4618	0.0000	1.0000	391	0

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Table 4.4.2 summarizes the values of the main variables examined in the willingness to pay analysis, after observations containing missing values were deleted. One of the principal reasons that observations were dropped was missing household income (47 missing values), which is fairly typical.

Table 4.4.2. Descriptive Statistics for the Estimation Sample

Variable	Mean	Standard Deviation	Minimum	Maximum	Valid	Missing
Rural	0.3432	0.4755	0.0000	1.0000	338	0
North	0.3432	0.4755	0.0000	1.0000	338	0
Central	0.3254	0.4692	0.0000	1.0000	338	0
South	0.3314	0.4714	0.0000	1.0000	338	0
Hispanic	0.1864	0.3900	0.0000	1.0000	338	0
Female	0.3402	0.4745	0.0000	1.0000	338	0
Income	62374.	43536.	7500.0	160000.	338	0
Elementary	0.0769	0.2669	0.0000	1.0000	338	0
High School	0.2396	0.4275	0.0000	1.0000	338	0
Ed3	0.3077	0.4622	0.0000	1.0000	338	0
Ed4	0.2160	0.4121	0.0000	1.0000	338	0
Ed5	0.1598	0.3669	0.0000	1.0000	338	0
Ed45	0.3757	0.4850	0.0000	1.0000	338	0
Educ	14.2840	2.3548	10.000	18.000	338	0
Health	1.7751	1.3704	0.0000	6.0000	338	0
Health2	0.8018	0.3993	0.0000	1.0000	338	0
Ncent	0.6686	0.4714	0.0000	1.0000	338	0

4.4.2 Contingent Valuation Analysis

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In this section of the survey, the salinity management program is described in detail, and the respondent is asked either one (single bound) or two (double bound) questions about their willingness to pay for the program. About 63 percent of the sample received the double bound format and 37 percent received the single bound (Table 4.5.1). The empirical estimation method is maximum likelihood, and seeks to maximize the probability that the pattern of yes and no responses actually observed is predicted by the model of a consumer's willingness to pay.

The next sections describe the probability statements used in the maximum likelihood estimation of response probabilities. For single bound respondents, a dichotomous choice model is used. For double bound respondents, two related but different models are estimated, the double bounded dichotomous choice model and the bivariate probit model. The next subsections explain each model briefly.

4.4.2.1 Single Bound Format (One wtp question)

The consumer is assumed to have willingness to pay represented by

$$wtp = \mathbf{X\beta} + \sigma\varepsilon,$$

where *wtp* is willingness to pay for the salinity program, **X** is a matrix of explanatory variables (the empirical form of which will be discussed below), β is a vector of coefficients, σ is a number representing the standard error of willingness to pay, and ε is a N(0,1) statistical error. When asked if s/he would pay an amount B^0 for the program, the probability that the respondent says "no" should be the probability that his or her *wtp* is less than B^0, or

$$\Pr(no) = \Pr(wtp < B^0)$$

$$= \Pr(\mathbf{X\beta} + \sigma\varepsilon < B^0)$$

$$= \Phi(\varepsilon < \frac{B^0 - \mathbf{X\beta}}{\sigma}),$$

where $= \Phi(\cdot)$ is the cumulative normal distribution function. Since there are two outcomes, the probability of observing a “yes” response is just 1.0 less the probability of a “no” response, or

$$\Pr(yes) = 1 - \Pr(yes)$$
$$= 1 - \Phi(\varepsilon < \frac{B^0 - \mathbf{X\beta}}{\sigma}).$$

4.4.2.2 Double Bound Format (Two wtp questions)

The double-bound format is identical to the single-bound format, except that a followup *wtp* question is asked, so that both responses can be analyzed together. In this format, if the person answers “yes” to the first *wtp* amount B^0, a second, higher amount B^H is asked, and the “yes” or “no” response is recorded. In similar fashion, a respondent answering “no” to B^0 is asked a lower followup amount B^L. This generates four observed response patterns: *yy* (“yes” to both questions), *yn* (“yes” to the first and “no” to the second), *ny* (“no” to the first and “yes” to the second), and *nn* (“no” to both questions).

Two principal ways of analyzing the pair of responses are used, depending on whether one treats the two responses as coming from two separate *wtp* distributions (one for the first response and one for the second), or as both coming from the same *wtp* equation. Treating the responses as coming from separate *wtp* distributions (a bivariate probit analysis) is common in telephone or personal interview surveys, where there is a distinct time delay between answering the first question and asking the second, and during that interval the respondent may reconsider or adjust their thinking about the good’s value. In this study, a mail survey was used, so that even though two questions were asked, both are seen simultaneously. This functions most similarly to a random payment card, the answers to which are usually treated as having a single *wtp* distribution (double-bounded dichotomous choice). It seems most reasonable to use the latter approach here, therefore, though both are investigated.

4.4.2.3 Double-Bounded Dichotomous Choice Probabilities

Here both answers are viewed as coming from a single *wtp* function. The probability of observing *nn* is

$$\Pr(nn) = \Pr(wtp < B^0, wtp < B^L)$$

$$= \Pr(wtp < B^L)$$

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$$= \Phi(\frac{B^L - \mathbf{X\beta}}{\sigma}),$$

Analogously to the single-bound case of a no response. Observing a "no" first and a "yes" second means that

$$\Pr(ny) = \Pr(B^L < wtp < B^0)$$

$$= \Phi(\frac{B^0 - \mathbf{X\beta}}{\sigma}) - \Phi(\frac{B^L - \mathbf{X\beta}}{\sigma}),$$

and the remaining two probabilities are

$$\Pr(ny) = \Phi(\frac{B^H - \mathbf{X\beta}}{\sigma}) - \Phi(\frac{B^0 - \mathbf{X\beta}}{\sigma})$$
$$\Pr(yy) = 1 - \Phi(\frac{B^H - \mathbf{X\beta}}{\sigma}).$$

4.4.2.4 Bivariate Probit Choice Probabilities

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With this model, each answer is viewed as coming from a separate *wtp* function. Since there are two responses, there are two wtp functions,

$$wtp_1 = \mathbf{X\beta}_1 + \sigma_1\varepsilon_1$$

and

$$wtp_2 = \mathbf{X\beta}_2 + \sigma_2\varepsilon_2,$$

and their errors can be expected to be correlated so a bivariate distribution (usually bivariate normal) is used to characterize the probabilities of the responses received. The probability of observing *nn* here is

$$\Pr(nn) = \Pr(wtp_1 < B^0, wtp_2 < B^L)$$

$$= \Pr(\mathbf{X\beta}_1 + \sigma_1\varepsilon_1 < B^0, \mathbf{X\beta}_2 + \sigma_2\varepsilon_2 < B^L)$$

$$= \Phi_2(\frac{B^L - \mathbf{X\beta}_1}{\sigma_1}, \frac{B^L - \mathbf{X\beta}_2}{\sigma_2}, \rho),$$

Where $\Phi_2(\cdot,\cdot,\rho)$ is the bivariate cumulative normal distribution and ρ is the correlation between the two *wtp* equations. Following the same logic, the probabilities of the other choice patterns are

$$\Pr(ny) = \Phi(\frac{B^0 - \mathbf{X\beta}_1}{\sigma_1}) - \Pr(nn)$$

$$\Pr(yn) = \Phi(\frac{B^H - \mathbf{X\beta}_2}{\sigma_2}) - \Pr(nn)$$

$$\Pr(yy) = 1 - \Pr(ny) - \Pr(yn) + \Pr(nn)$$

4.4.2.5 Likelihood Function

Since the estimation sample contains respondents from both the single-bound and double-bound formats, and the observations are independent, the log-likelihood functions for the contingent valuation analysis are

$$LL = \sum_{i \in sb} D_i \cdot \ln(\Pr(i)) + \sum_{j \in db} D_j \cdot \ln(\Pr(j)),$$

where $\Pr(i)$ refer to the single bound probability statements given above, $\Pr(j)$ are the probability statements for the double bound format (either dichotomous choice or bivariate probit, depending on the model; and D_i (D_j) are dummy variables taking the value 1 when response i (j) is given by the respondent.

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4.4.3 Estimation Results from the Contingent Valuation Analysis

The explanatory factors expected to be important in explaining the contingent valuation willingness to pay responses were expected to be: household income, with a positive (+) sign; number of health problems in the household (+), female gender of respondent (+), Rural (-), Hispanic (-), Education (+), presence of health-sensitive people in the household (+), and geographic location (no clear sign).

The estimation results for the single bound/double bound dichotomous choice model are given in Table 4.5.3. The signs on individual coefficients conform largely to *a priori* expectations. *Edu*, *Female*, and *Health* had a positive and statistically-significant signs, while *Hispanic* had the expected negative sign. In addition, the geographic variable *North* was significant with a positive sign. Variables addressed at differences in respondents' attitudes toward agriculture relative to the environment (*ProAg*, the difference between Likert scale (1-5) ratings of the importance of agriculture and the importance of the environment) and presence of young children or older adults in the household (*Hhu6)* were not significant. Several covariates were included as shifters of the standard error of *wtp*, but only one (North) played any appreciable role.

Table 4.4.3. Single/Double Bound Dichotomous Choice Estimates of Willingness to Pay for A Salinity Management Plan

Variable	Coefficient Estimate[a]

Mean of WTP	
Constant	-31.0024**[b]
	(10.7748)
RURAL1	-3.5714
	(3.0046)
EDU	1.7422**
	(0.6566)
INC	0.0302
	(0.0272)
NORTH	5.5200*
	(3.0641)
FEMALE	5.2833**
	(2.1029)
HISPANIC	-6.0242*
	(3.3318)
PROAG	-0.7315
	(1.8475)
HEALTH	1.8662**
	(0.7738)
HHU6	-0.0026
	(0.0031)
Standard Error of WTP	
C1	3.5014**
	(0.5261)
RURAL	-0.1461
	(0.2345)
EDU	-0.0568
	(0.0357)
INCOME	0.0347
	(0.0243)
NORTH	-0.4619**
	(0.2346)
Log-L	-258.6
Number of cases	322

[a] Standard errors in parentheses
[b] Significant at the 10% level (*), 5% level (**) one-tailed test

Predictions of willingness to pay for the Salinity Management Plan specified in the contingent valuation come from substituting the pararameter estimates from Table 4.4.3 into the *wtp* expression given earlier, applied to each person in the sample given the level of their covariates. Since we are interested in measuring a respondent's willingness to pay for the plan, a negative *wtp* is taken to mean the respondent would not pay anything for the plan. The results, summed across the sample, are given in Table 4.4.4.

Table 4.4.4. Estimated Willingness to Pay for A Salinity Management Plan: Contingent Valuation Results ($/month)

Variable	Mean	Std Dev	Minimum	Maximum	Number
Wtp|*wtp*>0	5.90	4.05	0.04	18.02	171
Wtp (full sample)	3.14	4.17	0.00	18.02	322

About 53% of the sample had positive willingness to pay for the Salinity Management Plan, and the mean payment per month from this group was $5.90. Averaged across the whole sample, including those not willing to pay anything, the mean *wtp* was $3.14/month.

The single bound dichotomous choice/bivariate probit double bound model results are presented in Table 4.4.5. Qualitatively, the results are similar to the previous model, though there are some differences in what is statistically significant. Two sets of coefficient estimates are generated for the bivariate probit part of the model, pertaining to the two *wtp* equations. The covariates of wtp_2 are defined as differences from their counterparts in wtp_1, but none of these was significant, beyond the constant term (C_2) and the standard error (σ_2). The correlation between wtp_1 and wtp_2 was moderate (0.31), and not statistically significant.

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Table 4.4.5. Single/Double Bound Dichotomous Choice Estimates of Willingness to Pay for A Salinity Management Plan

Variable	Coefficient Estimate[a]
First wtp Equation	
C_1	-13.4444
	(8.6352)
RURAL1	-2.3706
	(1.8532)
ED451	3.1031*[b]
	(1.8441)
INC1	0.0491**
	(0.0230)
NCENT1	3.2581*
	(1.8939)
FEMALE1	3.2183*
	(1.8121)
HISPANIC1	-2.4169
	(2.4471)
HEALTH1	1.4009**
	(0.6575)
Second wtp equation	
C_2	10.7964*
	(6.2432)
Standard Errors	
σ_1	2.8891**
	(0.3337)
σ_2	-0.7409**
Correlation	(0.3066)
ρ	0.6617
	(0.4844)
Log-L	-205.9
Number of cases	338

[a] Standard errors in parentheses
[b] Significant at the 10% level (*), 5% level (**) one-tailed test

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As with the single/double bound dichotomous choice model, the willingness to pay estimates are generated for each person in the sample using their covariates and the coefficients from

Table 4.4.5, with negative values taken to mean zero *wtp* for the salinity management plan. As there are two *wtp* equations, there are two *wtp* estimates, corresponding to responses to the first and second questions, respectively (Table 4.4.6). There is a substantial literature on why the first and second equation estimates of *wtp* are often different in bivariate probit models, but this goes beyond our purpose here. A practical solution is to take the mean of the two sets of estimates, which would imply a willingness of approximately $3.28 per month averaged across the whole sample.

Table 4.4.6. Estimated Willingness to Pay for A Salinity Management Plan: Contingent Valuation Results ($/month)

Variable	Mean	Std Dev	Minimum	Maximum	Number
$wtp_1 \mid wtp_1 > 0$	2.30	2.16	4.67	9.04	48
$wtp_2 \mid wtp_2 > 0$	6.85	3.86	14.86	19.83	312
wtp_1 (full sample)	0.32	1.13	1.28	9.04	338
wtp_2 (full sample)	6.24	4.17	17.40	19.83	338

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4.4.4 Choice Experiments Analysis

The choice experiments involve a best choice of salinity management program from 3 alternatives. The standard models for estimation are logit models, of which there are two common types. Standard logits explain the probability of choosing a particular alternative as a function of the attributes of the alternative and demographics of the chooser. A well-known limitation of standard logits is that the ratio of the probabilities of choosing any two alternatives is independent of the presence or absence of other alternatives (also known as independence of irrelevant alternatives). The nested logit model relaxes this assumption by presuming there is a hierarchy of choice among attributes. While the choice of how alternatives nest matters in the nested logit, and can seem arbitrary in settings where there is a large number of attributes, in the present setting there is a clear nesting structure. Two of the alternatives (Plan A and Plan B) are clear departures from the status quo (No Plan), so it is natural to presume that the respondent first decides whether or not to choose a new salinity management plan (A or B), and then to choose which between A and B s/he prefers. The nested logit model encompasses the standard logit as a special case, so it is straightforward to test whether the nested or standard logit provides a better fit to the data.

The logit framework is slightly different from the contingent valuation framework, in that it begins with the respondent's indirect utility function (rather than willingness to pay) as a function of observable characteristics of the choices and the chooser. Writing indirect utility of salinity management plans as

(Plan A) $V_A = C_p + \beta X_A + \alpha Y_p + \varepsilon_A,$

(Plan B) $V_B = C_p + \beta X_B + \alpha Y_p + \varepsilon_B,$

(No Plan) $V_N = \beta X_N + \varepsilon_N,$

where C_p and Y_p are an alternative-specific constant and covariates for the first-level choice of whether to choose something other than status quo (i.e., A or B), and X_i, i=A, B, N are the attributes of each specific management plan, with a suitable distributional assumption on the random errors ε_i, i=A, B, N, the nested logit (unconditional) probabilities of choosing each alternative are

$$P(NP) = \frac{e^{X_N\beta}}{e^{Y_p\alpha+\theta_p \ln(e^{X_A\beta}+e^{X_B\beta})} + e^{X_N\beta}}$$

$$P(A) = \frac{e^{X_A\beta+Y_p\alpha+(\theta_p-1)\cdot\ln(e^{X_A\beta}+e^{X_B\beta})}}{e^{Y_p\alpha+\theta_p \ln(e^{X_A\beta}+e^{X_B\beta})} + e^{X_N\beta}}$$

and

$$P(B) = \frac{e^{X_B\beta+Y_p\alpha+(\theta_p-1)\cdot\ln(e^{X_A\beta}+e^{X_B\beta})}}{e^{Y_p\alpha+\theta_p \ln(e^{X_A\beta}+e^{X_B\beta})} + e^{X_N\beta}}.$$

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The standard logit holds in the special case where $\theta_p = 1$, and in this case the choice probbilities become

$$P(NP) = \frac{e^{Y_{np}\alpha+\theta_{np}X_N\beta}}{e^{Y_{prg}\alpha+X_A\beta} + e^{Y_{prg}\alpha+X_B\beta} + e^{X_N\beta}}$$

$$P(A) = \frac{e^{X_A\beta+Y_{prg}\alpha+(\theta_p-1)\cdot\ln(e^{X_A\beta}+e^{X_B\beta})}}{e^{Y_{prg}\alpha+\theta_p \ln(e^{X_A\beta}+e^{X_B\beta})} + e^{Y_{np}\alpha+\theta_{np}X_N\beta}}$$

and

$$P(B) = \frac{e^{X_B\beta+Y_{prg}\alpha+(\theta_p-1)\cdot\ln(e^{X_A\beta}+e^{X_B\beta})}}{e^{Y_{prg}\alpha+\theta_p \ln(e^{X_A\beta}+e^{X_B\beta})} + e^{Y_{np}\alpha+\theta_{np}X_N\beta}}.$$

4.4.5 Estimation Results from the Choice Experiments Analysis

The results of the nested and standard logit model estimation are presented in Table 4.4.7. There are a few more observations in this analysis than in the *wtp* analysis, because several unfruitful variables (notably young and old household members and attitudes toward agriculture relative to the environment) were dropped from the analysis. In the standard logit analysis, acres of agricultural land preserved, premature deaths, and cost are highly significant attributes of the salinity management plans, with the expected signs. In addition, the demographic characteristics of the choosers are highly significant, also with the expected signs. *Income*, *edu*, *female*, and *health* problems are all positive, while *Hispanic* has a negative sign. However, this model is restrictive in that it holds the parameter θ_p equal to 1. In the Nested Logit column, which relaxes this restriction, it can be seen that θ_p is significantly different from zero and (more to the point here) is significantly different from 1. This indicates that the data reject the standard logit restriction, and the nested logit, not surprisingly, provides a significantly better fit overall. In this model, while the demographic variables remain strongly significant, the attributes of individual salinity management plans become less significant, with only cost and premature deaths showing significance (with the correct signs). Even though specific attributes of Plan A and Plan B are less significant, the demographic factors all enter the model as program-specific constants, meaning that they are explaining the decision to choose a plan (A or B) over the status quo (No Plan). Thus the model shows strong significance of the decision to choose (and pay for) a plan to manage and limit salinity, although the specific attributes of A and B are less important. This is perhaps not surprising, in light of the earlier discussion about how the public goods aspects of salinity management are subtle and indirect.

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Table 4.4.7. Nested and Standard Logit Estimates of Utility Function Coefficients from the Choice Experiments

Variable	Standard Logit[a]	Nested Logit[a]
AGLAND	0.8833**[b]	0.2230
	(0.3715)	(0.2476)
WETLAND	-0.0004	-0.0002
	(0.0029)	(0.0016)
PDEATH	-0.5490**	-0.2278*
	(0.1340)	(0.1285)
COST	-0.0672**	-0.0243*
	(0.0089)	(0.0130)
θ_p	1.0000	0.3149**
	.	(0.1590)
PROGASC	-2.8780**	-2.4438**
	(0.7387)	(0.5797)
INCOME	0.0072**	0.0070**
	(0.0018)	(0.0018)
EDU	0.1304**	0.1283**
	(0.0319)	(0.0315)
HISPANIC -	0.4621**	-0.4459**
	(0.1711)	(0.1690)
FEMALE	1.0720**	1.0495**
	(0.1490)	(0.1475)
HEALTH	0.2085**	0.2022**
	(0.0484)	(0.0479)
Log-L	-1089.8	-1083.0
Number of cases	338	338

[a] Standard errors in parentheses
[b] Significant at the 10% level (*), 5% level (**) one-tailed test

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The coefficients in Table 4.4.7 are the coefficients of indirect utility behind the observed choices in the choice experiments. These can be used to evaluate any level of provision of each of the public goods attributes, in addition to providing a salinity management plan that controls salinity but provides the same level of public goods as the status quo (No Plan).

Since only premature deaths was statistically significant (in addition to cost) in the statistically-superior nested logit model, estimates of willingness to pay are provided in Table 4.4.8 for the three levels of this public good. In addition, an estimate is provided for the scenario where there is no change in the associated public goods when the salinity management plan that halts the increase in salinity is put in place.

Table 4.4.8. Estimated Willingness to Pay for A Salinity Management Plan: Choice Experiments Results ($/month)

Scenario	Mean	Std Dev	Minimum	Maximum	Number
Full Sample					
No Change in Public goods	4.75	19.30	0.00	159.68	338
Premature Deaths are:					
10,100/year	6.42	22.78	0.00	174.54	338
9,500/year	10.76	29.95	0.00	201.28	338
8,900/year	14.90	35.30	0.00	219.11	338
Wtp is positive					
No Change in Public goods	50.20	41.17	2.76	159.68	32
Premature Deaths are:					
10,100/year	49.28	43.66	1.21	174.54	44
9,500/year	55.96	46.42	0.72	201.28	65
8,900/year	55.94	48.94	0.27	219.11	90

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Averaged across the whole sample, willingness to pay for a salinity management plan that provides no change in public goods is $4.75 per month, while willingness to pay ranges from $6.42 per month to $14.90 per month for increasing improvements in air quality along with salinity control. However, the bottom part of Table 4.4.8 shows that according to this model, the willingness to pay is highly concentrated among a minority of respondents who are willing to pay substantial amounts ($50-56 per month), and that most people are not willing to pay anything.

5 SUMMARY

5.1 Direct Costs of Salinity in the Central Valley

The following pie charts and histograms provide a summary of the magnitude and sources of the salinity load in the central valley, and the projected direct economic costs that these salt loads will impose on the economy in 2030. As shown in Shoups and Hopmans ( ) the net increase in the saline load in the San Joaquin and Tulare valleys induces changes in the shallow saline groundwater areas and the average salinity of the deep aquifer. In calculating the economic effects we only consider the effects of perched saline water on agriculture and ignore the relatively small yield effect that an increase of 170 ppm in groundwater salinity by 2030 will have on crop yields due to the use of groundwater for irrigation. If the deep groundwater salinity is concentrated more in certain areas then the local increase in salinity could be significantly higher with consequently larger reductions in crop yields. Thus the direct losses to crop agriculture are slightly understated.

For confined animal operations the largest direct cost of salinity increase is in the loss of field crop area to use for waste disposal. Another smaller effect of the loss of field crop acres is its effect on the cost of animal fodder, principally alfalfa. This cost could be estimated by updating a regional multi-state model of the alfalfa industry such as Konyar and Knapp (1991) However this was beyond the scope of this current study.

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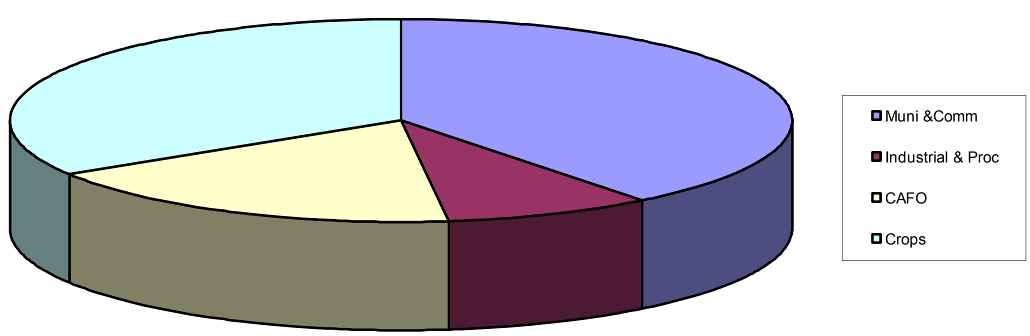

Figure 5.1.1 Salt Loads-Central Valley-2005.

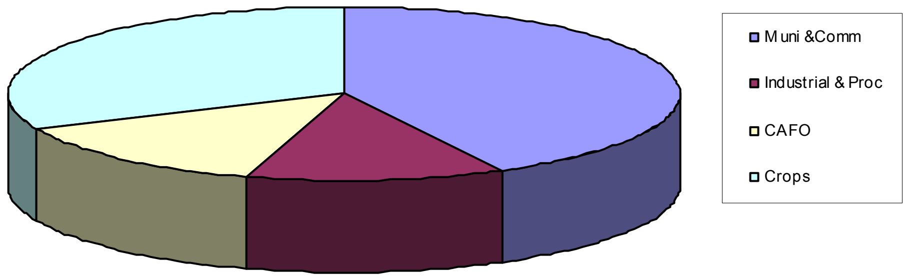

Figure 5.1.2. Salt Loads Central Valley 2030

Figures 5.1.1 and 5.1.2 show the shift in the source of salt loads in the valley over the next 25 years. The proportional contribution from municipal, commercial, and industrial sources will increase significantly during the period. In contrast, the proportional contribution from agriculture and CAFO s decreases. This assumes that the enforcement of nutrient disposal from CAFOs will improve slightly.

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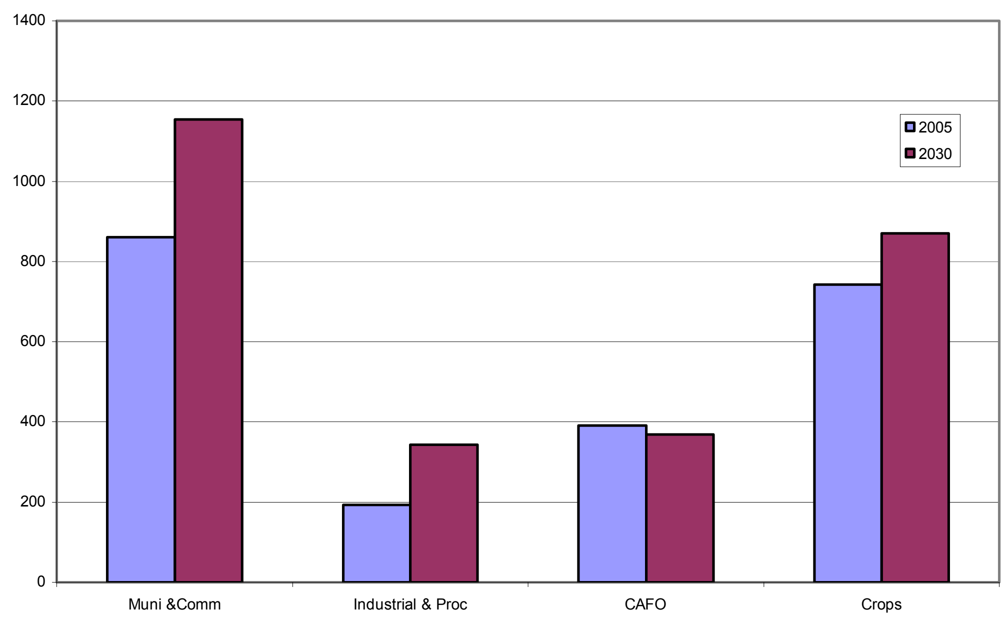

Figure 5.1.3. Salt Loads Central Valley (1000 tons/pa).

Figure 5.1.3 shows the change in the tons of salt accumulating in the valley. The total contribution from CAFOs decreases slightly while that from irrigated agriculture increases. The greatest increase is in salt generated from municipal and commercial processes, but industrial production shows a greater proportional increase

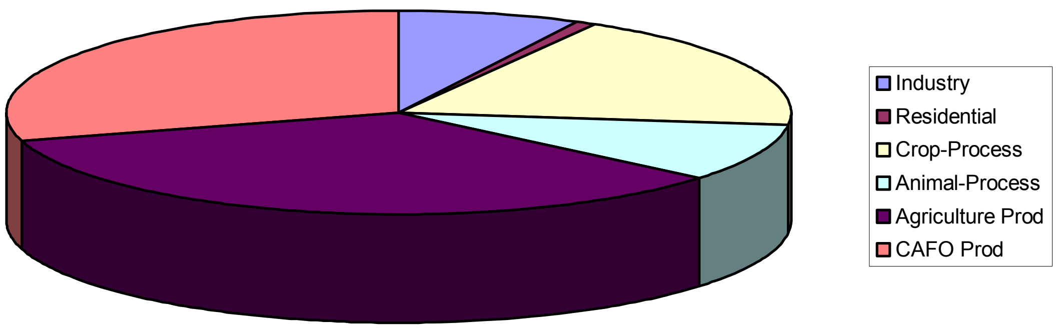

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Figure 5.1.4. Central Valley Direct Salinity Costs-2030.

Figure 5.1.4 shows the industries in the valley that bear most of the cost of accumulated salinity in 2030 crop agriculture and CAFOs still bear the majority of the cost despite their reduction in the proportional contribution shown in Figure 5.1.3. Crop and animal processing industries also bear a large proportion of the costs. Comparing the costs with Figure 5.1.3 shows that crop agriculture and CAFOs bear a greater proportional cost burden than their proportion of salinity generation.

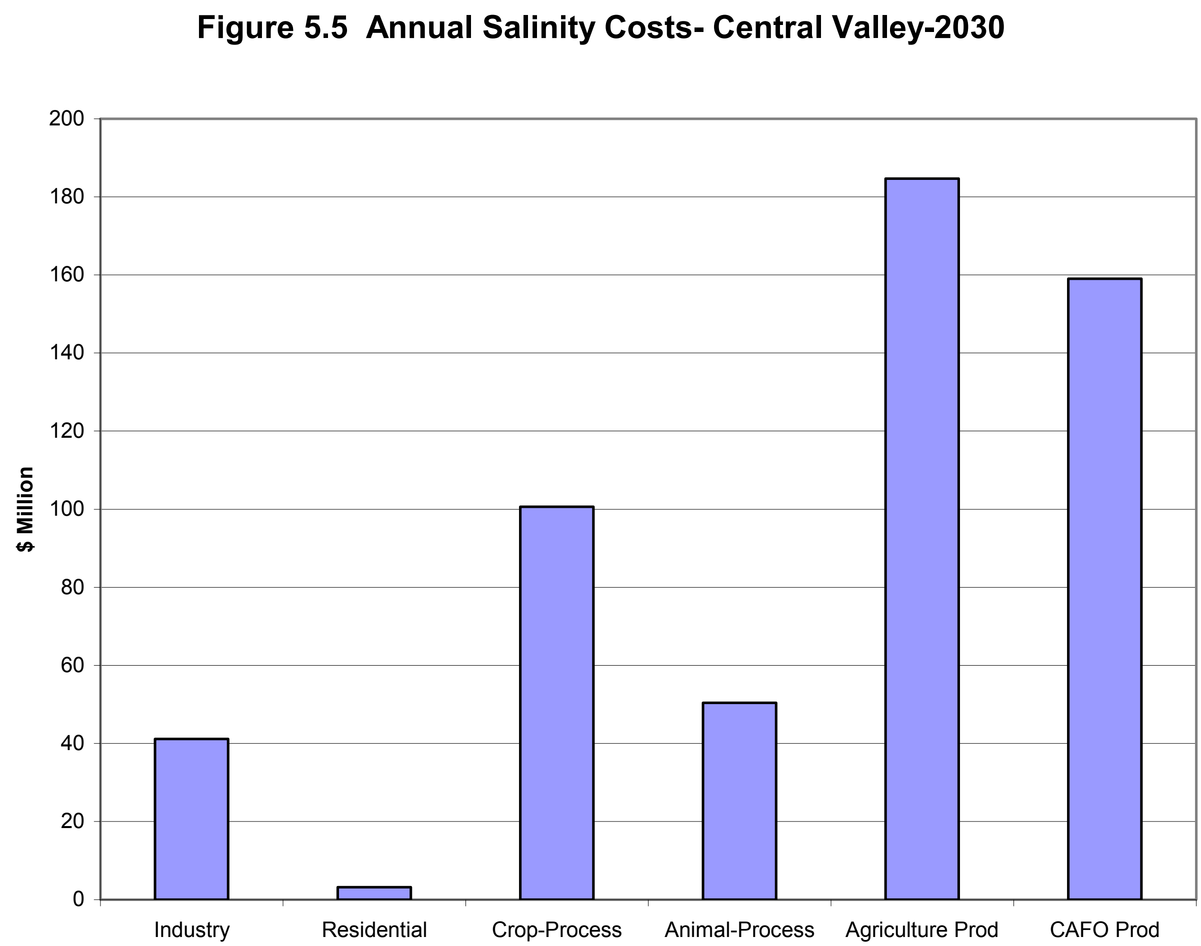

Figure 5.1.5. Annual Salinity Costs- Central Valley-203

Figure 5.1.5 shows the annual cost of salinity in 2030 measured in millions of dollars. It is clear that the large proportion of cost burden is imposed on agricultural and processing industries.

Table 5.1.1. Annual Salinity Costs- Central Valley- 2030

Direct Costs	$Million pa	$Million pa
Industry	41.13	
Residential	3.21	
Crop-Process	100.6	
Animal-Process	50.4	
Agriculture Prod	184.7	
CAFO Prod	159.05	
Total Direct Cost		539
Indirect Costs		
Valley Income	682	
State Income	211	
Total Indirect Income Loss		941
Employment		
Valley Jobs	23,919	
Statewide Jobs	4,154	
Total Job Loss		29,270
Non-Market costs (2008)		78.5

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Table 5.1.1 summarizes the economic impacts of increasing salinity in the San Joaquin and Tulare valleys in 2030. The results show very significant economic costs if salinity continues to accumulate at the same average rate as recent years. The direct annual economic costs and 2030 (measured in $2004) a substantial at 539 million the year. The indirect costs of the valley are further 682 million dollars, and indirect costs to the rest of California are found to be an additional 259 million dollars.

Increasing salinity will reduce job formation in the valley by 23,919 jobs. Of these jobs, many are drawn from the Hispanic community. In addition, the California economy will also lose another 4,154 jobs due to the increase in salinity.

Nonmarket costs in terms of the willingness to pay to remove salinity effects averaged $57 a year per household, yielding 2008 annual value of $78.5 million.

All these measures show that the effects of allowing salinity to accumulate at the present rate, whether measured by direct economic costs of lost production, in direct effects on income in the Central Valley and California as a whole are very significant. In addition, the nonmarket measures of jobs lost due to salinity increase, and the willingness to pay to avoid salinity effects also showed substantial costs of inaction.

5.2 Caveats and Suggestions for Additional Research

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